ANNUAL REPORT

OF THE

BOARD OF REGENTS

OF THE

SMITHSONIAN INSTITUTION,

SHOWING

THE OPERATIONS, EXPENDITURES, AND CONDITION OF THE INSTITUTION

FOR

THE YEAR 1884.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

[FORTY-EIGHTH CONGRESS, SECOND SESSION.]

IN THE SENATE OF THE UNITED STATES,
January 27, 1885.

Resolved by the Senate (the House of Representatives concurring), That the annual report of the Smithsonian Institution and National Museum for the year 1884 be printed, and that there be printed 16,060 extra copies; of which 3,000 copies shall be for the use of the Senate, 6,060 for the House of Representatives, and 7,000 for the Smithsonian Institution.

Agreed to by the House of Representatives, February 4, 1885.

LETTER

FROM THE

SECRETARY OF THE SMITHSONIAN INSTITUTION,

ACCOMPANYING

***The annual report of the Board of Regents of that Institution for the year* 1884.**

JANUARY 27, 1885.—Ordered to be printed.

SMITHSONIAN INSTITUTION,
Washington, D. C., January 25, 1885.

SIR: In accordance with section 5593 of the Revised Statutes of the United States, I have the honor in behalf of the Board of Regents to submit to Congress the annual report of the operations, expenditures, and condition of the Smithsonian Institution for the year 1884.

I have the honor to be, very respectfully, your obedient servant,

SPENCER F. BAIRD,
Secretary Smithsonian Institution.

Hon. G. F. EDMUNDS,
President of the Senate.

Hon. JOHN G. CARLISLE,
Speaker of the House of Representatives.

ANNUAL REPORT OF THE SMITHSONIAN INSTITUTION FOR THE YEAR 1884.

SUBJECTS.

1. Proceedings of the Board of Regents for the session of January, 1885.

2. Report of the Executive Committee, exhibiting the financial affairs of the Institution, including a statement of the Smithson fund, and receipts and expenditures for the year 1884, and the estimates for 1885.

3. Annual report of the Secretary, giving an account of the operations and condition of the Institution for the year 1884, with the statistics of collections, exchanges, &c.

4. General appendix, comprising a record of recent progress in the principal departments of science, and special memoirs, original and selected, of interest to collaborators and correspondents of the Institution, teachers, and others engaged in the promotion of knowledge.

The report of the Assistant Director and Curators of the National Museum for the year 1884 will be published in a separate volume.

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REPORT OF THE SECRETARY.

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REGENTS OF THE SMITHSONIAN INSTITUTION.

By the organizing act approved August 10, 1846, Revised Statutes, title LXXIII, section 5580, "The business of the Institution shall be conducted at the city of Washington by a Board of Regents, named the Regents of the Smithsonian Institution, to be composed of the Vice-President, the Chief Justice of the United States [and the Governor of the District of Columbia], three members of the Senate, and three members of the House of Representatives, together with six other persons, other than members of Congress, two of whom shall be resident in the city of Washington, and the other four shall be inhabitants of some State, but no two of the same State."

REGENTS FOR THE YEAR 1884.

	Term expires.
The Vice-President of the United States:	
GEORGE F. EDMUNDS (elected President of Senate March 3, 1883)	Mar. 3, 1885

The Chief Justice of the United States:
MORRISON R. WAITE.

United States Senators:	
NATHANIEL P. HILL (from May 19, 1881)	Mar. 3, 1885
SAMUEL B. MAXEY (from May 19, 1881)	Mar. 3, 1887
JUSTIN S. MORRILL (appointed February 21, 1883)	Mar. 3, 1885
Members of the House of Representatives:	
OTHO R. SINGLETON (appointed January 7, 1884)	Dec. 23, 1885
WM. L. WILSON (appointed January 7, 1884)	Dec. 23, 1885
WM. W. PHELPS (appointed January 7, 1884)	Dec. 23, 1885
Citizens of Washington:	
PETER PARKER (first appointed in 1868) ....Resigned	Apr., 7, 1884
WILLIAM T. SHERMAN (first appointed in 1871)	Mar. 25, 1885
JAMES C. WELLING	May 13, 1890
Citizens of a State:	
JOHN MACLEAN, of New Jersey (first appointed in 1868)	Dec. 19, 1885
ASA GRAY, of Massachusetts (first appointed in 1874)	Dec. 19, 1885
HENRY COPPÉE, of Pennsylvania (first appointed in 1874)	Dec. 19, 1885
NOAH PORTER, of Connecticut (appointed in 1878)	Mar. 3, 1890

MORRISON R. WAITE, Chancellor of the Institution and *President of the Board of Regents.*

JOURNAL OF PROCEEDINGS OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION.

WASHINGTON, D. C., *January* 21, 1885.

The annual meeting of the Board of Regents of the Smithsonian Institution was held this day at half-past 10 o'clock, a. m.

Present: Hon. G. F. EDMUNDS, Hon. J. S. MORRILL, Hon. S. B. MAXEY, Hon. O. R. SINGLETON, Hon. W. L. WILSON, Hon. W. W. PHELPS, Rev. Dr. JOHN MACLEAN, Rev. Dr. NOAH PORTER, Dr. HENRY COPPÉE, Dr. JAMES C. WELLING, and the Secretary, Professor BAIRD.

Excuses for non-attendance were read from Chief-Justice Waite, Prof. Asa Gray, and Hon. N. P. Hill.

In the absence of the Chancellor, on motion of Mr. Phelps, Dr. PORTER was called to the chair.

The journal of the Board was read and approved.

The Secretary stated that the Rev. Dr. NOAH PORTER had been re-elected a Regent for six years by the joint resolution of Congress, approved March 3, 1884.

The Secretary presented to the Board the following letter:

Prof. SPENCER F. BAIRD,
Secretary of the Smithsonian Institution:

DEAR SIR: The state of my health renders it necessary to tender my resignation as a member of the Board of Regents of the Smithsonian Institution.

In signifying my resignation it is with no ordinary feelings I recall the years I have been connected with the Board and the distinguished men with whom it has been my privilege and honor to be associated. Not only the present members whom I so highly respect and esteem, but a long list of honored names of former members now deceased, recur to me, the last of which is that of Professor JOSEPH HENRY, and while JAMES SMITHSON will be known to the world and remembered as the founder of the Institution, JOSEPH HENRY will be regarded as having been raised up by a signal Providence, the true interpreter of his will, the able organizer of the Institution, and wise controller of its finances.

May the Smithsonian Institution, so auspiciously established and extensively known, continue, under your wise administration, an establishment *distinct* and *specific*, for the "increase and diffusion of knowledge among men."

With great respect, your friend and servant,

PETER PARKER.

2 LAFAYETTE SQUARE,
Washington, D. C., April 7, 1884.

The Secretary informed the Board that Congress had filled the vacancy occasioned by the resignation of Dr. Parker by the election of Dr. JAMES C. WELLING, president of Columbian University of Washington, D. C., for six years from May 13, 1884.

On motion of Dr. Maclean it was—

Resolved, That the Board of Regents has heard with regret of the resignation of Dr. Peter Parker, and hereby expresses the high appreciation of the valuable and efficient services he has rendered the Institution for the past seventeen years as a Regent and as Chairman of its Executive Committee.

The Secretary stated that in accordance with the rules of the Board during its recess, the remaining members of the Executive Committee had filled the vacancy occasioned by the resignation of Dr. Parker, by the appointment of Dr. Welling.

On motion of Dr. Coppée it was—

Resolved, That Dr. Welling be elected to fill the vacancy in the Executive Committee.

The Secretary reported that in accordance with the request of the Board at its last meeting, Senator Edmunds had prepared a bill relative to the provision for an Acting Secretary, which had passed Congress and become a law on the 13th of May, 1884, as follows:

An act to provide for the appointment of an Acting Secretary of the Smithsonian Institution.

[Public No. 31, Forty-eighth Congress, first session.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Chancellor of the Smithsonian Institution may, by an instrument in writing filed in the office of the Secretary thereof, designate and appoint a suitable person to act as Secretary of the Institution when there shall be a vacancy in said office, and whenever the Secretary shall be unable from illness, absence, or other cause to perform the duties of his office; and in such case the person so appointed may perform all the duties imposed on the Secretary by law until the vacancy shall be filled or such inability shall cease. The said Chancellor may change such designation and appointment from time to time as the Institution may in his judgment require.

Approved, May 13, 1884.

Under the provisions of this act the Chancellor had taken the following action:

LYME, CONN., *July* 2, 1884.

By virtue of the authority conferred on me by the act of May 13, 1884, "to provide for the appointment of an Acting Secretary of the Smithsonian Institution," I hereby designate and appoint Mr. WILLIAM J. RHEES to act as Secretary of the Institution when there shall be a vacancy in that office, and whenever the Secretary shall be unable from illness, absence, or other cause to perform the duties of his office.

M. R. WAITE,
Chancellor of the Smithsonian Institution.

Dr. Maclean presented the annual report of the Executive Committee, which was read.

On motion of Dr. Coppée it was—

Resolved, That the report of the Executive Committee be accepted, and that the income for the year 1885, be appropriated for the service of the Institution upon the basis of the above report; to be expended by the Secretary with full discretion as to the items, subject to the approval of the Executive Committee.

The Secretary presented the following communication he had received since the last meeting of the Board:

JUNE 2, 1884.

SPENCER F. BAIRD,
Secretary Smithsonian Institution,
Washington, D. C.:

SIR: I intend to make a bequest for the advancement of science—that is, of physical science. For many reasons I would like to make the bequest in favor of the Smithsonian Institution; but there is one difficulty which must be cleared up before I can decide. If money were left by will to the Smithsonian Institution would it defend the will against the claims of any and all persons who should contest the will and take legal steps to set it aside? Has it authority by law; has it funds that it would be authorized to use for the purpose of defending a will in its favor? As I have no children the will would be less likely to be contested, but there are others who might attempt to set it aside. For this reason what I wish above all to be assured of is that any legacy that I leave for the purpose named will not be given up without making a fight of it if needful. Please explain this point.

I wish you to send me a form of words, the very words themselves, in which a bequest should be made so that there could be no pretense of setting it aside for vagueness; and that will carry out my intentions, which I will explain:

The chief part I would desire to bequeath to the Institution would be for the "increase and diffusion of knowledge among men," and beside would wish to have the Institution invest say $300 (is that too insignificant for the purpose?) and use the income thereof for conferring a gold medal either annually or biennially (which would be the better?) on the person who had made the most important discovery in physical science during the year, or two years ending, say a year before the date of conferring the medal. For example, the Regents would have to decide, say in the month of December, 1883, who made the most important discovery in physical science during the year, or two years, ending December 31, 1882. If you have my meaning put it in language that will make it perfectly clear without multiplying words.

The medal not for any patented invention, like the electric light, for example, but especially and only for such discoveries as Pasteur on infection, fermentation, &c., and G. Darwin's on tidal action. Regents to be sole judges as to what is meant by physical science and most important discoveries therein.

The reason why I would like to have not only suggestions and explanations but the full "I will and bequest to" is also because I don't know whether to say the Regents shall do this or that, or whether to say a majority or quorum of them shall do it in order to make it both strictly legal and also practicable; also, whether or not it is necessary to say how the Regents shall invest the money. I suppose a copy of that part

of Hamilton's or Huebus' (Habel ?) will would answer for the part relating to the "increase and diffusion," &c. As for the medal I believe no fund has been left to institutions for that purpose, and I should like to have your opinion on it.

Please return this letter with your answer, which I would like you to let me have as soon as you can; taking, however, all the time you need to make it so full and explicit that no further correspondence will be necessary at this stage. I mean business if your answer is satisfactory. For the present I desire this affair to be treated as confidential, or if necessary to mention to other parties, withhold the name.

There is one thing I had rather do than make a bequest in favor of the Institution, namely, pay over a certain sum, say $2,000 or $2,500, in trust to the Regents; provided I could receive the income during life, the Institution to have the sole use and possession of the same after my death. Would the Institution be authorized to accept a sum of money on such terms?

Respectfully,

* * * *

After full discussion of the subject it was, on motion of Mr. Edmunds—

Resolved, That the communication be referred to the Executive Committee with full power to act in relation to it.

The Secretary, Professor Baird, presented his annual report of the operations of the institution for the year 1884, which was read in part.

On motion of Dr. Maclean, the Secretary was instructed to transmit the report to Congress.

On motion of Mr. Edmunds, it was—

Resolved (1), That the fiscal year of the Institution shall hereafter terminate on the 30th day of June in each year.

(2) That the Secretary shall hereafter prepare and cause to be printed and sent to each member of the Board on or before the first day of December in each year, his annual report.

(3) That the annual meeting of the Board of Regents shall hereafter be held on the second Wednesday in January in each year.

The Board then adjourned *sine die*.

REPORT OF THE EXECUTIVE COMMITTEE OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION FOR THE YEAR 1884.

The Executive Committee of the Board of Regents of the Smithsonian Institution respectfully submit the following report in relation to the funds of the Institution, the appropriations by Congress for the National Museum and other purposes, the receipts and expenditures for the Institution and the Museum, for 1884, and the estimates for the year 1885.

Condition of the fund January 3, 1885.

The amount of the bequest of James Smithson deposited in the Treasury of the United States (act of Congress August 10, 1846)	$515,169 00
Residuary legacy of Smithson, added to the fund, deposited in the Treasury of the United States (act of Congress February 8, 1867)	26,210 63
Addition to the fund from savings, &c. (act of Congress February 8, 1867)	108,620 37
Addition to the fund by bequest of James Hamilton, of Pennsylvania (1884)	1,000 00
Addition to the fund by bequest of Simeon Habel, of New York (1880)	500 00
Addition to the fund by proceeds of sale of Virginia bonds (1881)	51,500 00
Total permanent Smithson fund in the Treasury of the United States, bearing interest at 6 per cent. per annum	$703,000 00

Statement of the receipts and expenditures of the Smithsonian Institution for the year 1884.

RECEIPTS.

Interest on the Smithson fund	$42,180 00	
Repayment of expenses of freight, &c., on Henry statue, by act of Congress	900 00	
Balance cash on hand January 1, 1884	25,914 20	
Total receipts		$68,994 20

EXPENDITURES.

Building:		
Repairs and improvements	$2,205 74	
Furniture and fixtures	2,423 90	
		$4,629 64
General expenses:		
Meetings of the Board	469 75	
Postage and telegraph	337 44	
Stationery	522 82	
General printing, blanks, &c	922 58	
Incidentals, horse, carriage, gas, &c	1,250 00	
Books, periodicals, and binding	2,528 25	
Salaries, Secretary, clerks, assistants, and labor	16,591 19	
		22,622 03
Publications and researches:		
Smithsonian Contributions to Knowledge	3,100 93	
Smithsonian Miscellaneous Collections	4,939 59	
Smithsonian Annual Report	2,834 53	
Explorations	2,881 16	
Apparatus	94 77	
Literary and scientific exchanges in addition to appropriation by Congress	2,510 71	
		16,361 69
Total expenditures		43,613 36
Balance, January, 1885		$25,380 84

ESTIMATES FOR 1885.

The following are the estimates of receipts by the Institution for the year 1885, and of the appropriations required for carrying on its operations during the same period:

Receipts.

Interest on the permanent fund receivable July 1, 1885, and January 1, 1886	$42,180 00

Expenditures.

For building and repairs	$1,500 00
For general expenses, including salaries	23,000 00
For Publications and researches	12,000 00
For Exchanges	3,000 00
For Contingencies	2,680 00
Total	$42,180 00

NATIONAL MUSEUM, AND OTHER OBJECTS COMMITTED BY CONGRESS TO THE SMITHSONIAN INSTITUTION.

The following appropriations were made at the first session of the Forty-eighth Congress for the National Museum, and other objects committed to the care of the Smithsonian Institution:

For the preservation and exhibition and increase of the collections received from the surveying and exploring expeditions of the Government, and other sources, including salaries or compensation of all necessary employés	$91,000 00	
For transfer and arrangement of the collections of the American Institute of Mining Engineers, presented to the Government, including expenses already incurred	10,000 00	
For expense of heating, lighting, and telephonic and electrical service for the new Museum building	6,000 00	
		$107,000 00
For care of the Armory building and grounds and expense of watching, preservation, and storage of the duplicate collections of the Government, and of the property of the United States Fish Commission contained therein, including salaries or compensation of all necessary employés		2,500 00
For cases, furniture, and fixtures required for the exhibition of the collections of the United States National Museum, and for salaries or compensation of all necessary employés		40,000 00
For the expenses of an international exchange of books, documents, and productions of the United States with foreign countries, in accordance with the Paris convention of 1877, including salaries and compensation to all necessary employés, to be expended under the direction of the Secretary of the Smithsonian Institution		10,000 00
For finishing, heating, gas-fitting, plumbing, and completely furnishing the eastern portion of the Smithsonian Institution, and for finishing the fourth and fifth stories, including liabilities already incurred		15,000 00
For paving sidewalk on south and east fronts of National Museum building		1,000 00
For expense of freight on statue of Joseph Henry from Rome to Washington, and all expenses by the Smithsonian Institution connected with the erection and ceremonies of unveiling said statue		900 00

For the purpose of continuing ethnological researches among the American Indians, under the direction of the Secretary of the Smithsonian Institution, including salaries and compensation of all necessary employés....... $40,000 00

Exhibit of condition of appropriations by Congress for National Museum, &c., January 1, 1885.

Object.	Balance January 1, 1884.	Appropriated for fiscal year 1884-'85, act July 7, 1884.	Total available from January 1, 1884, to June 30, 1885.	Expended in the year 1884.	Balance January 1, 1885, available till June 30, 1885.
Preservation of collections, National Museum	$46,658 51	$107,000 00	$153,658 51	$100,259 24	$53,399 27
Armory Building, National Museum	1,525 50	2,500 00	4,025 50	2,525 00	1,500 50
Furniture and fixtures, National Museum	36,020 49	40,000 00	76,020 49	63,384 13	12,636 36
International Exchanges	3,500 00	10,000 00	13,500 00	7,705 50	5,794 50
Reconstruction eastern portion Smithsonian building	12,677 14	15,000 00	27,677 14	26,378 92	1,298 22
Paving sidewalk, National Museum	....	1,000 00	1,000 00	....	1,000 00
North American Ethnology	19,945 40	40,000 00	59,945 40	40,419 78	19,525 62

The balance (January 1, 1884), $802.17, of the appropriation for preparing the scientific report of the Polaris expedition, has been expended during the year, according to the certificate of Major Hobbs, October 6, 1884, disbursing clerk of the Treasury Department.

The appropriation by Congress of $900 to reimburse the Institution for its expenditures in connection with the Henry statue, was received from the Treasury Department in October, 1884, and is included in the statement of receipts for the year.

The committee has examined the vouchers for payments made from the Smithson income during the year 1884, all of which bear the approval of the Secretary of the Institution, and a certificate that the materials and services charged were applied to the purposes of the Institution.

The committee has also examined the accounts of the National Museum and find that the balances above given correspond with the certificates of the disbursing officers of the Interior and Treasury Departments.

The quarterly and annual accounts-current, the check-books and journals have been examined and found correct.

Respectfully submitted.

JOHN MACLEAN,
W. T. SHERMAN,
JAMES C. WELLING,
Executive Committee.

WASHINGTON, *January*, 1885.

Dr. Maclean's examination of the expenditures and vouchers was limited to those of the Smithsonian Institution proper.

REPORT OF THE ARCHITECTS FOR THE RECONSTRUCTION OF THE EASTERN PORTION OF THE SMITHSONIAN INSTITUTION.

Prof. S. F. BAIRD,

Secretary of the Smithsonian Institution:

SIR: We have the honor to submit a report of the operations pertaining to the fire-proof reconstruction of the east portion of the Smithsonian building, which was commenced in the month of April, 1883, and completed during the last year.

For a proper understanding of the conditions under which this work was executed it may be well to recall a few steps in the life of the whole building.

On the 28th of January, 1847, the plans of James Renwick, esq., of New York, were adopted, bids for the completion of the whole building were invited, the work awarded on the 9th of March, and the corner-stone laid on the 1st of May following. Five years were stipulated for the completion of the work under the building contract.

On the 26th of February, 1850, the interior framing and floors of part of the center building, intended to contain the museum of apparatus, fell down into the basement before completion, and on July 3, 1850, a committee of the Regents of the Institution reported "that the interior of the main building is defective in the kind of material originally adopted and to a considerable degree in the quality of the material employed, which consists principally of wood. The money was mainly expended upon the cut-stone work of the fronts." The committee recommended "that the interior of the center building be removed and that a *fire-proof* structure be substituted for it."

In January, 1853, the plans of Capt. B. S. Alexander, U. S. A., for fire-proofing and finishing the interior of the center building were adopted, and the author of the plans intrusted with the superintendence of this work, which was commenced in June, 1853, and completed in December, 1854. It included a lecture room with unsurpassed optical and acoustic properties, accommodating 1,800 persons. Unfortunately for the building the term "fire-proofing" had in those days simply reference to floors and walls, so that the fire-proofed center building still retained a combustible wooden roof, like all other public buildings erected about the same time.

A fire occurred on the 24th of January, 1865, which destroyed this roof, and with it all the interior of the upper story of the main building and the adjacent towers. The executive committee of the Regents re-

ported that careful survey forced upon them the conviction that "the original construction of the building as a whole was very defective and unsuited as a receptacle of valuable records. The two wings and connecting ranges, which were not injured by the fire, are defective in material and construction. The floors in some cases, though covered with flagging, rest upon wooden beams, which are decayed, and in a few years the interior of these parts will require removal."

The Regents decided that the restoration should in all parts be indestructible by fire, and intrusted Adolf Cluss, architect, with the plans and superintendence of the work, which was carried on shortly after the close of the war, when material and labor had risen to the highest mark.

The second story of the center building was fitted up as a hall for Government collections, and was covered with an iron and slate roof; five towers were fitted up with iron and brick floors, partitions, and roofs, and with iron stairs. This work was completed in the season of 1867. Fire-proof floors were substituted in 1871 for the decayed lower wooden floors of the west wing and of the northwest arcade, and in 1873 a steam-heating apparatus was put in the building.

The east wing, then called the chemical wing, was originally arranged for one large lecture-room, provided with seats for 1,000 persons, and the adjoining range was fitted up for two apparatus-rooms in close proximity with the lecturers' table. When the improved lecture-room in the main building was completed in 1854 there was no longer any use for the now antiquated room which absorbed the whole east wing. Hence, this wing was temporarily divided into two stories, with wooden floors, and studded, lathed, and plastered partitions. The lower floor was arranged in a large room for handling all articles of exchange, &c. The second story was fitted up with a suit of rooms for the accommodation of the Secretary of the Institution, in accordance with the original intentions of the Regents, and the high space above was left unfinished as a loft.

The fenestration became, in the newly arranged two stories, most anomalous. The tall windows of a lofty lecture-room being subdivided, the old frames came to be in the lower story very near to the ceiling, and almost on a level with the floor in the upper story. The connecting wing, as altered, accommodated simply two middle-sized offices, with the cloister along the exposed north front, through the open arches of which rain and snow drifted, and rotted the wooden floor-joists so much that they had to be temporarily supported from the cellar. Before long the open arches of the cloister had to be filled in with temporary wooden windows, which barely kept the weather out.

Above the first story of the range there was a second story, of no practical value, since the external architecture limited the size of its windows to bull's-eyes of 2½ feet in diameter, &c.

The museum was shut off from the eastern main entrance by direct obstructions and by floors on two different levels.

This deplorable condition of the east wing, continued for a series of years, demanded in the end prompt action, and in March, 1883, an appropriation of $50,000 was made by Congress for the fire-proof reconstruction of the eastern part of the Smithsonian Institution, to which $15,000 were added in July, 1884, for completion and furniture.

Under these appropriations the old "chemical wing" was stripped of the combustible constructions; so much of the exterior walls as depended upon the wooden frame work was carefully taken down; all ornamental cut-stone work, consisting of copies from doors, windows, and cornices of divers monastic edifices in France and Germany, was laid aside and reset in the walls during the progress of the work. The dark and damp cellar, containing 4,500 square feet of floor space, was drained, and provided with a Portland cement floor upon a concrete foundation, and converted into dry working-rooms in best sanitary condition. On the ground floor cheerful offices were arranged on both sides of a broad and level corridor, by which the old museum is reached in a direct line from the east entrance. The formerly useless and anomalous second story was rearranged into two stories of ten feet clear height for offices, with adequate light and air, and covered with a metal roof, fastened in a fire-proof manner upon concreted brick arches.

Above the ground floor of the east wing there were but six badly lighted and ventilated rooms in a second story. These were replaced by seven well lighted and aired spacious offices, and a similar space was gained in each of two upper stories for offices and document-rooms. This wing is crowned by a pitched mediæval wrought-iron roof, covered with slate hung to iron pur-lines for the steep portions, and with metal upon hollow terra-cotta tiles for the flat portions.

There are arranged above the basement, in all, 36 office rooms, containing 12,500 square feet floor space.

In the progress of the work the exterior walls were strengthened, substantial brick walls were built for the interior partitions, and supports of the fire-proof floors consisting of concreted brick arches sprung between rolled-iron beams.

All the rooms are provided with extra large gas-pipes and flues ending above the roof, so that eventually either of them may be used by the scientists for experiments. There are tubes laid throughout for intercommunication by means of oral annunciators, and piping for clocks.

Documents may be raised or lowered from the outside of the building to the basement by a hoist, and from there distributed to the archives in the different stories by means of an elevator of cheap construction.

A compact low-pressure steam-heating apparatus warms the whole section promptly and comfortably at a moderate expense.

The exterior architecture was simply modified by resetting all the architraves and cornices at such levels as to enable valuable space within the building to be made useful for laboratories, offices, workrooms, archives, and store-rooms, by enlarging some of the windows as

necessary for the new conditions, by supplying a small quantity of plain cut stone, and by adding Norman dormers of cut-stone work for lighting the space within the pitched roof of the west wing.

A financial statement accompanies this report, which gives the cost of all branches of the work in detail and requires no comment.

With the completion of the work, as above reported upon, the principal part of the Smithsonian building is now, from foundation to roof, beyond the reach of any serious fire. Still the reconstruction is not complete as long as the west wing and adjoining range above the ground floor are of combustible construction. During a conflagration in those combustible parts of the building, the main building in the center would probably be considerably damaged by water.

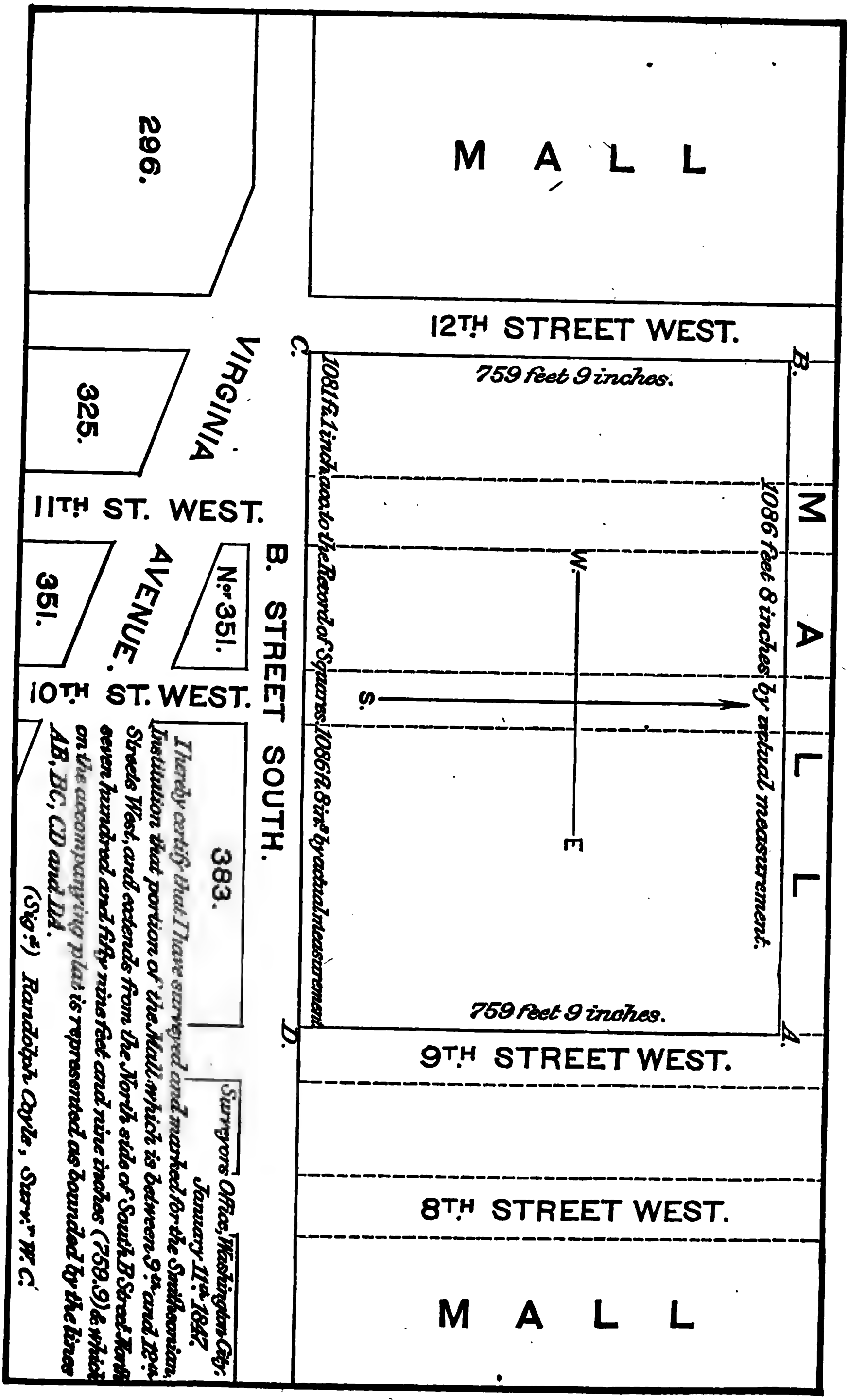
In the center building some repairs are necessary, and the first story ought to be re-arranged, so that the available space can be made more useful for the purposes of the Institution.

We have the honor to be, very respectfully, your most obed't,

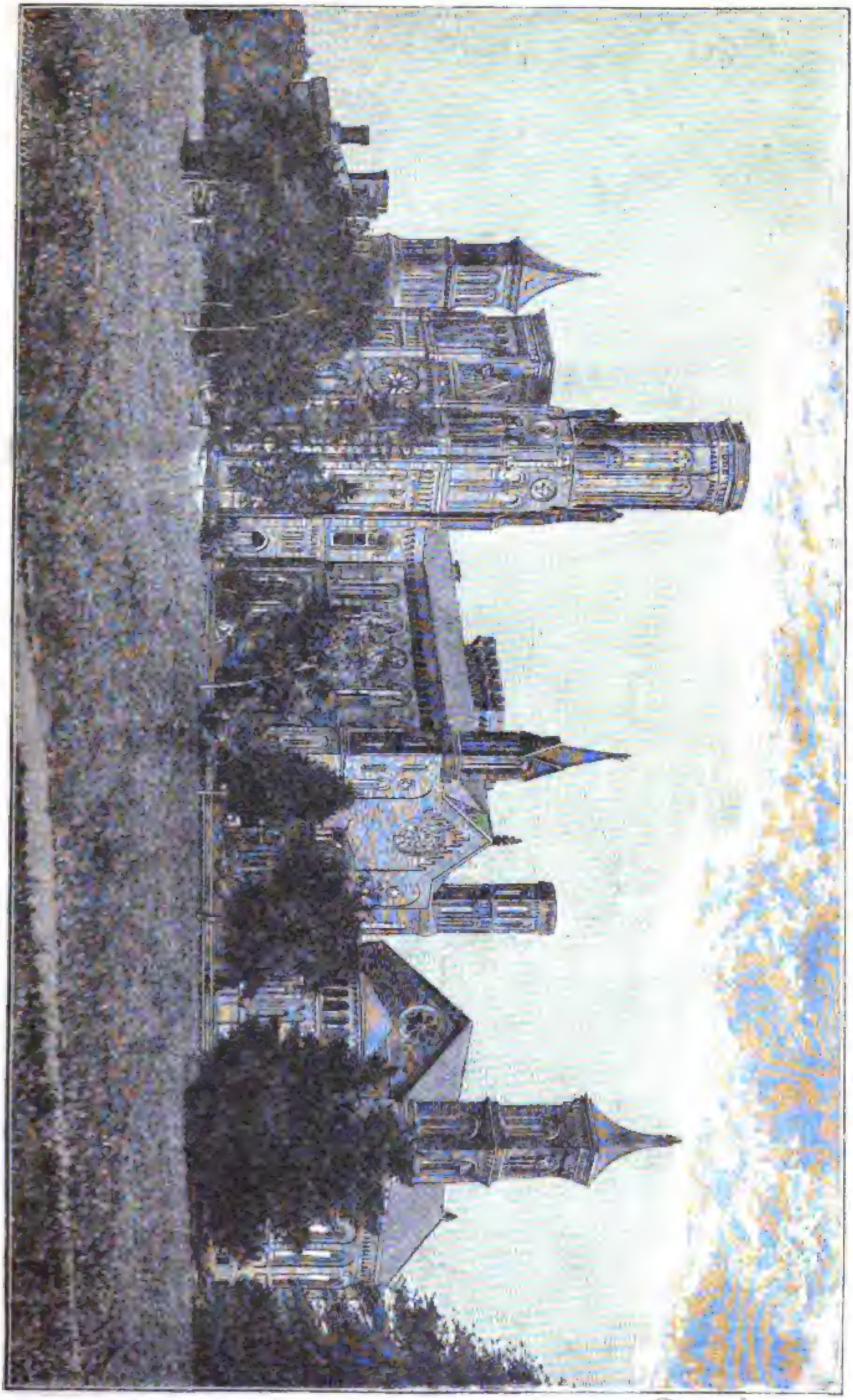
CLUSS & SCHULZE,
Architects.

WASHINGTON, D. C.,
January 12, 1885.

PLANS AND VIEWS OF THE GROUNDS AND BUILDING OF THE SMITHSONIAN INSTITUTION.



PLAN OF THE SMITHSONIAN GROUNDS. (APPROPRIATED BY ACT OF CONGRESS, AUGUST 10, 1846.)

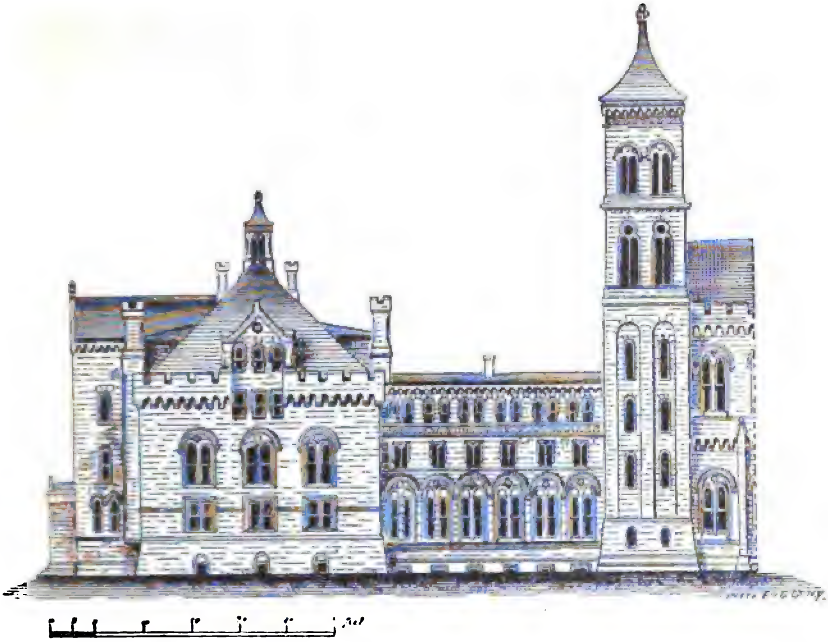


NORTH FRONT OF THE SMITHSONIAN INSTITUTION (SHOWING THE ORIGINAL FORM OF THE EAST PORTION—ON THE LEFT SIDE).

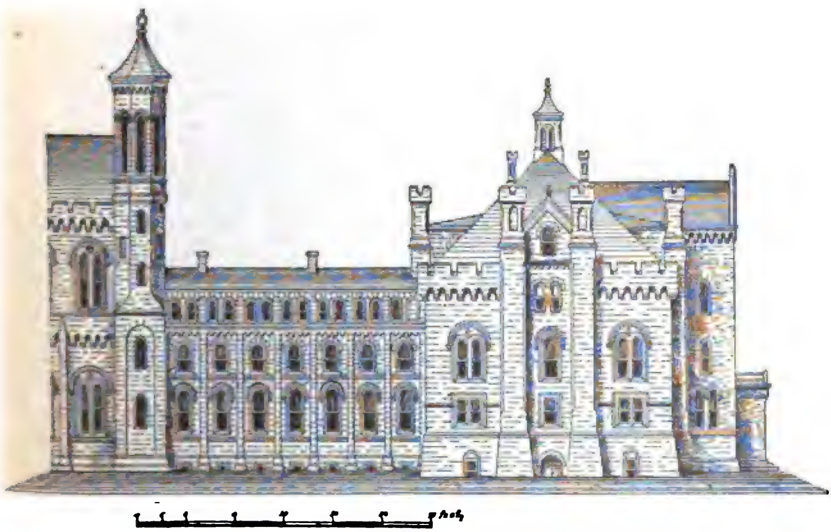
Plate 3.

X

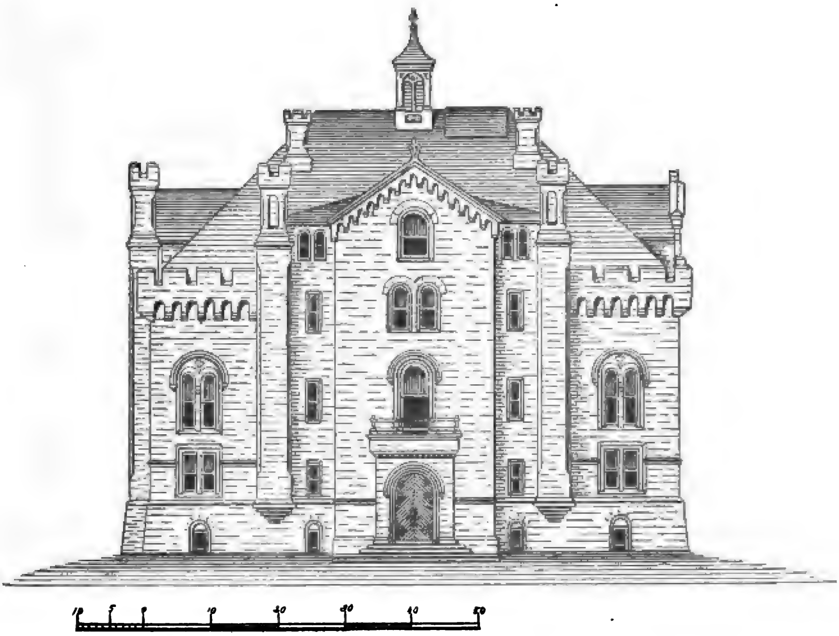
SOUTH FRONT OF THE SMITHSONIAN INSTITUTION (SHOWING THE RECONSTRUCTED FORM OF THE EAST PORTION ON THE RIGHT SIDE).



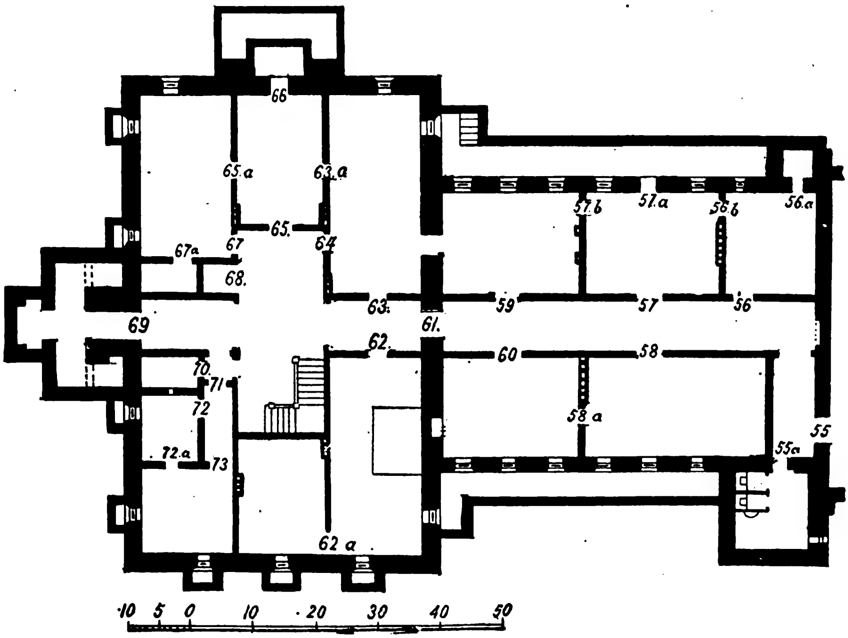
EASTERN PORTION OF SMITHSONIAN INSTITUTION—NORTH ELEVATION.



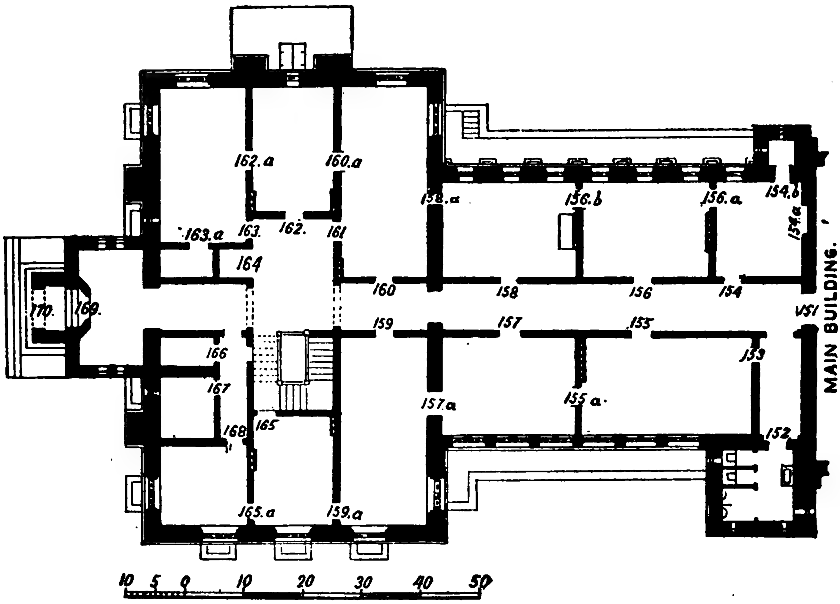
EASTERN PORTION OF SMITHSONIAN INSTITUTION—SOUTH ELEVATION.



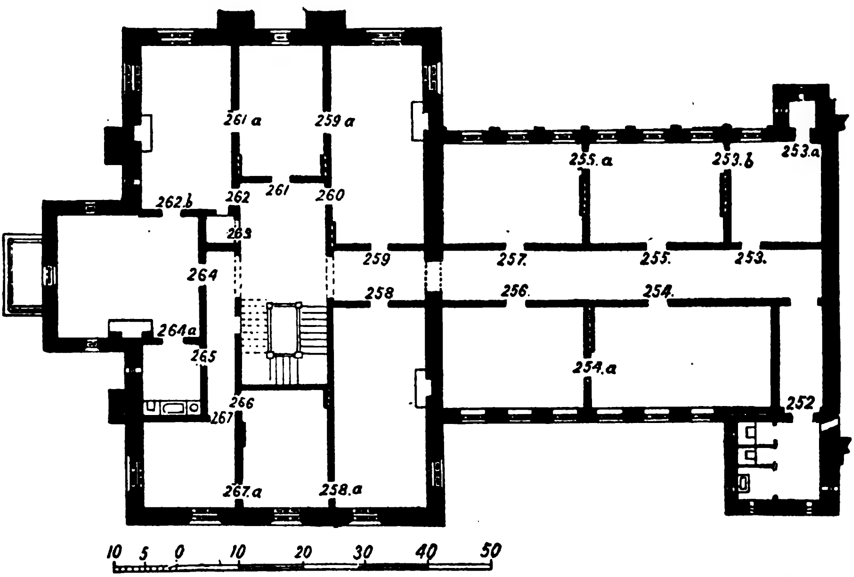
EASTERN PORTION OF SMITHSONIAN INSTITUTION—EAST ELEVATION.



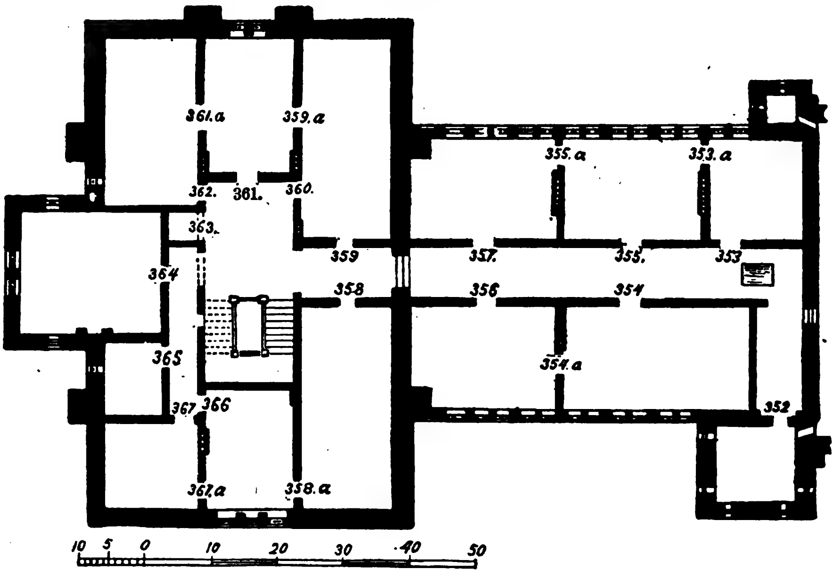
EASTERN PORTION OF SMITHSONIAN INSTITUTION—PLAN OF BASEMENT.



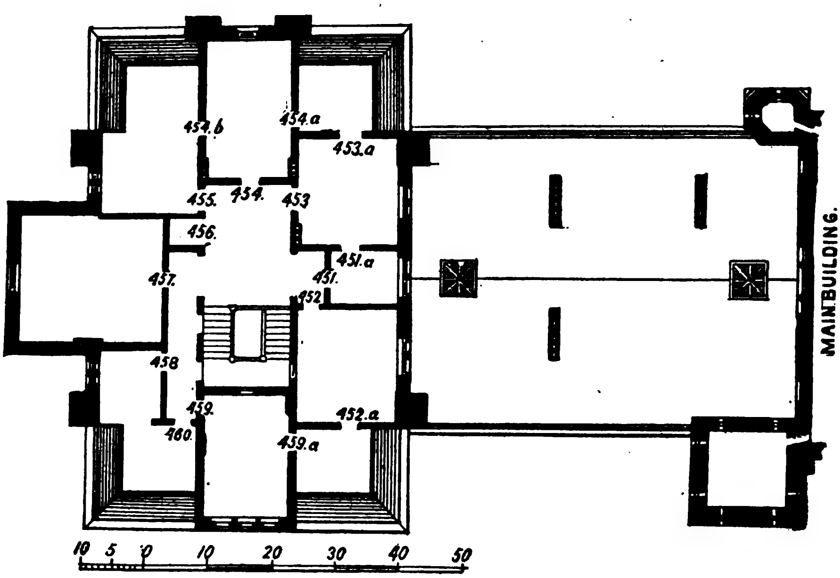
EASTERN PORTION OF SMITHSONIAN INSTITUTION—PLAN OF FIRST STORY.



EASTERN PORTION OF SMITHSONIAN INSTITUTION—PLAN OF SECOND STORY.



EASTERN PORTION OF SMITHSONIAN INSTITUTION—PLAN OF THIRD STORY.



EASTERN PORTION OF SMITHSONIAN INSTITUTION—PLAN OF FOURTH STORY.

THE SMITHSONIAN INSTITUTION.

MEMBERS EX OFFICIO OF THE "ESTABLISHMENT."

(January 1, 1885.)

CHESTER A. ARTHUR, President of the United States.
G. F. EDMUNDS, President of the United States Senate.
MORRISON R. WAITE, Chief Justice of the United States.
FREDERICK T. FRELINGHUYSEN, Secretary of State.
HUGH McCULLOCH, Secretary of the Treasury.
ROBERT T. LINCOLN, Secretary of War.
WILLIAM E. CHANDLER, Secretary of the Navy.
FRANK HATTON, Postmaster-General.
HENRY M. TELLER, Secretary of the Interior.
BENJAMIN H. BREWSTER, Attorney-General.
BENJAMIN BUTTERWORTH, Commissioner of Patents.

REGENTS OF THE INSTITUTION.

(January 1, 1885.)

MORRISON R. WAITE, Chief Justice of the United States, *President of the Board.*
G. F. EDMUNDS, President of the United States Senate.
NATHANIEL P. HILL, member of the Senate of the United States.
SAMUEL B. MAXEY, member of the Senate of the United States.
J. S. MORRILL, member of the Senate of the United States.
O. R. SINGLETON, member of the House of Representatives.
WILLIAM L. WILSON, member of the House of Representatives.
W. W. PHELPS, member of the House of Representatives.
JOHN MACLEAN, citizen of New Jersey.
ASA GRAY, citizen of Massachusetts.
HENRY COPPÉE, citizen of Pennsylvania.
NOAH PORTER, citizen of Connecticut.
WILLIAM T. SHERMAN, citizen of Washington, D. C.
JAMES C. WELLING, citizen of Washington, D. C.

Executive Committee of the Board of Regents.

JOHN MACLEAN. WILLIAM T. SHERMAN. JAMES C. WELLING.

SPENCER F. BAIRD, Secretary of the Institution and Director of the U. S. National Museum.

REPORT OF PROFESSOR BAIRD,

SECRETARY OF THE SMITHSONIAN INSTITUTION, FOR 1884.

To the Board of Regents of the Smithsonian Institution:

GENTLEMEN: I have the honor to present herewith the report of the operations and condition of the Smithsonian Institution for the year 1884. This, in accordance with the usual custom, will include an account of the work performed by the Smithsonian Institution itself, as well as that of the branches of the public service placed by Congress under its charge, namely, the National Museum and the Bureau of Ethnology. To this will be added a sketch of the work of the United States Fish Commission, which is also under my charge; and of that of the U. S. Geological Survey, kindly furnished by its Director.

THE SMITHSONIAN INSTITUTION.

INTRODUCTORY.

Outside of the regular routine work of the Institution, an account of which will be furnished in its proper place, are the details connected with the participation, in 1884, by the Smithsonian Institution in the exhibitions at Cincinnati, Louisville, and the International Cotton Exposition at New Orleans, with which your Board was charged by order of Congress. A full account of the history of these undertakings will be given hereafter.

An increasing number of national organizations for the promotion of science has received accommodation in the lecture-room of the National Museum during the year, in accordance with the authority of the Board.

The repairs to the eastern portion of the Smithsonian building have been completed, with the exception of a few minor details, and the offices re-established.

The general progress of the Institution during the year, and that of the public service under its control, has been satisfactory. The Smithsonian funds are in good condition, the new year being entered upon free from any indebtedness and with a satisfactory balance on hand.

The publications of the Institution have been continued, and numerous additions have been made to the library. The work of the International Exchange service continues to increase, and will, it is hoped,

be placed upon a still more definite and satisfactory basis during the year 1885.

The additions to the Museum have been unexampled in extent, consequent partly upon the acquisitions made in connection with the exhibitions just referred to, and partly upon the labors of the Geological Survey, of the Ethnological Bureau, of the United States Fish Commission, and of numerous miscellaneous explorations, both public and private.

THE HENRY STATUE.

The appropriation of $15,000, made some years ago by Congress, for the erection of the Henry statue did not quite cover all the expenses, and the sum of $900 was advanced from the funds of the Institution. Believing, however, that it was the intent of Congress that this statue should be placed in position without cost to the Institution, application was made for the sum named, which was duly allowed. The money has been paid over and placed to the credit of the Institution.

PROFESSOR HENRY'S SCIENTIFIC WRITINGS.

At the meeting of the Board of Regents of January 17, 1883, a resolution was introduced by Dr. Maclean to provide for the republication of Professor Henry's scientific writings. A committee appointed at the last meeting of the Board, January 16, 1884, consisting of Prof. Asa Gray, Hon. William L. Wilson, and your Secretary, has had the subject under consideration, and has decided that the resolution only covered such of Professor Henry's articles as had actually been printed, and especially the portion prior to his entrance upon his duties at Washington. The editing of this publication was intrusted to Mr. Wm. B. Taylor, who has been engaged in collecting the necessary material. The commencement of the work has gone to press, and a sample is submitted for the information and criticism of the Regents.

JAMES SMITHSON.

In the Life of Smithson,* published by the Institution a few years ago, the author, Mr. Rhees, says: "It is an interesting subject of speculation to consider the motives which actuated Smithson in bequeathing his fortune to the United States of America, to found an institution in the city of Washington. He is not known to have had a single correspondent in America, and in none of his papers is found any reference to it or to its distinguished men. It has been alleged that he was more friendly to monarchical than to republican institutions, but there appears to be no foundation for this opinion. * * * By selecting the United States as the depository of his trust he paid the highest compli-

*"Smithson and his Bequest." Smithsonian Miscellaneous Collections, No. 330, 1880, p. 18. And Smithsonian Annual Report for 1879.

ment to its intelligence and integrity, and testified his confidence in republican institutions and his faith in their perpetuity."

It is gratifying to be able to confirm this supposition by information which has recently been communicated to this Institution. The following letters from a grandson of Davies Gilbert, president of the Royal Society, and an intimate friend of Smithson, were received during the past year:

ENYS, PENRYN, CORNWALL, ENGLAND,
March 13, 1884.

Prof. S. F. BAIRD,
Secretary Smithsonian Institution:

SIR: Some years since I noticed, while I was living in New Zealand, an advertisement for any letters or information relating to Mr. Smithson, addressed especially to descendants of Sir Davies Gilbert and others.

On my return to England I came across a letter written by Smithson, dated Paris, May 9, year 4, (1792), under his first name, James L. Macie, and addressed to my grandfather, Mr. Davies Gilbert (*never* SIR). Should you wish for a copy of this letter and any information relative to his passing at Oxford, and short notes by my grandfather written in his pocket-book, I shall be glad to send them.

I shodld have inclosed copies, but fear the 'life' projected may be long since published.

Yours, truly,
JOHN D. ENYS.

ATHENÆUM CLUB, PALL MALL, S. W.,
May 16, 1884.

MY DEAR SIR: I have lately returned from fishing in Scotland, and write to acknowledge your answer to my letter *re Smithson.*

On my return to Cornwall next month I will copy from my grandfather's pocket-books the entries relating to him as Mr. Macie, and forward a copy of the only letter I know of from him written from Paris when the Revolution was first under way.

I shall be grateful if you could forward me here, or to my address in Cornwall, any life or account of Mr. Smithson such as you have already published.

Yours, truly,
JOHN D. ENYS.

ENYS, PENRYN, CORNWALL,
August 23, 1884.

MY DEAR SIR: I am afraid that the following extract from my grandfather's pocket-books and addresses to the Royal Society of London will be of very slight value to you. I know of no other letter of his, but any under the *not* familiar name of Macie I have no doubt were long ago burnt. Should any further information turn up I will forward it.

I shall be glad to hear if you think right to publish the inclosed, which

were written on the leaves bound up in Mr. Davies Gilbert's pocket-books, and should like copies of any information which has been published before.

You are at liberty to destroy the extracts or publish them, as you think best towards Smithson's memory.

Yours, truly,
JOHN D. ENYS.

Note under the week from June 8–14, 1789. *In bound-up pocket-book of Davies Gilbert, F. R. S., M. T., &c.*

"Macie, afterwards Smithson, was a Gent. Com. when I entered at Pembroke College.

"His mother's husband was a country gentleman, to whose estates he has succeeded; but the first Duke of Northumberland was allowed on all hands to be his father. At the time of his matriculation I have heard that a blank was left for his surnames, Mr. Macie having at that period instituted suit to annul his marriage, which the wife defended. The Dutchess of N. then died, when Mrs. Macie wished the marriage dissolved, with the hope of marrying the Duke of N., but this the husband from spite opposed, and I have heard that a suit was actually instituted in which the parties had changed sides. Pending these matters Mr. Macie died, and my friend succeeded to his estate. The Duke of Northumberland did not marry the mother, nor, I believe, did he notice Macie in his will, certainly not beyond a small legacy. Yet on that event Macie had the bad taste (not to use a stronger expression) to obtain the King's authority for taking the name of Smithson (his putative father's), he still continuing to usurpe and wrongfully hold, by his own admission, the property of the Macie's.

"Mr. Smithson has lived chiefly abroad, with manners and habits more foreign than English. He is living unmarried in 1826. * * * Several ingenious papers in the Phil: Transactions and other periodical works here and on the Continent under the names James Smithson and James Macie. D. G."

"In the college register it is usual, after incerting the Christian and surnames of the person admitted, to add Filius Richardi (for instance) Armigeri or Generosus, but not repeating the surname.

"In Mr. Macie's case the addition is Filius Armigeri, omitting his father's name altogether. D. G."

Note in bound copy of MS. pocket-book kept by Davies Gilbert.

"MAY 26, 1786.

"On this day Mr. James Louis Macie (afterwards Smithson) was created Master of Arts in the Convocation House. I remember his being seated on the upper end of the bench, on the floor, on the proctor's left hand; that we walked back together, when Macie exchanged his cap for

a hat, and then walked with me round Christ Church meadows. What is very curious his father's name is omitted and he is merely stated to be the son of an esquire."

"For some account of Mr. James Smithson Macie see Gentleman's Magazine for March, 1830, p. 275."

"Extract translated from the college register: "1786, May 7, James Louis (or Lewis) Macie, æt. 17, of London, son of an esquire, matriculated of Pembroke College, Oxford."

"Under June 11th, 1789: "Macie introduced me to Sir Joseph Banks at the Royal Society."

Letter from James Smithson to Davies Gilbert.

"PARIS, *May 9th*, Year 4 [1792].

"DEAR SIR: Your letter did not reach London till after I was come out of town, and followed me here. I really take it exceedingly ill of you to have forgot my crystals, and beg of you to make quick and ample atonement for it. I do not now remember what particular ones I requested you to procure me, but any you bring shall, king-like, be graciously received, as a testimony of your good intentions. Well! Things are going on! *Ça ira* is growing the song of England, of Europe, as well as of France. Men of every rank are joining in the chorus. Stupidity and guilt have had a long reign, and it begins, indeed, to be time for justice and common sense to have their turn. The office which you have been lately named to will, I hope, afford you means of promoting their cause. Every Englishman I converse with, almost every Englishman I see or hear of, appears to be of the democratic party. Mr. Davis, high sheriff for Dorsetshire, left this town today and takes with him, it seems, a quantity of tricolor ribbon to deck his men with the French national cockades, and I do not think this example unworthy of imitation by those whose principles lead them to consider with indifference and contempt the frowns of the court party, to whom, doubtless, the mixture of red, white, and blue is an object of horror. I do not tell you news of this country, as the English papers inform you pretty faithfully of the manner in which it goes on. You have understood, I hope, that the church is now here quite unacknowledged by the state, and is indeed allowed to exist only till they have leisure to give it the final death-stroke. Mr. Louis Bourbon is still at Paris, and the office of king is not yet abolished, but they daily feel the inutility, or rather great inconvenience, of continuing it, and its duration will probably not be long. May other nations, at the time of their reforms, be wise enough to cast off, at first, the contemptible incumbrance. I consider a nation with a king as a man who takes a lion as

a guard-dog—if he knocks out his teeth he renders him useless, while if he leaves the lion his teeth the lion eats him.

"I remain, dear sir, yours, very sincerely,

"JAMES L. MACIE.

"I beg of you to make my best compliments to your father. A letter directed as follows will reach me: Monsieur Macie, Hotel de Parc Royal, Rue de Colombier, F. S. G., A Paris.

"To DAVIES GIDDY,* Esq.,

"*Tredred, near Marazian, Cornwall, Angleterre.*"

This letter is indorsed by Davies Gilbert (formerly Giddy): "*Smithson.* J. L. Macie. 1792. May the 9th."

Mr. Davies Gilbert was sheriff of Cornwall in 1792.

THE BOARD OF REGENTS.

It is with regret that I announce the resignation of Hon. Peter Parker, on April 17, 1884, of the office of member of the Board of Regents and of the Executive Committee. Dr. Parker has performed these functions for many years, and always with zeal and fidelity. His advancing years and the great amount of labor required from the Executive Committee in the way of auditing the accounts of the Institution, &c., made him firm in insisting upon the acceptance of his resignation against many protests. His place was accordingly filled by Congress by the election of Dr. James C. Welling, president of Columbian University of this city, on May 13. Dr. Welling was requested by the remainder of the Executive Committee—General Sherman and Rev. Dr. Maclean—to take Dr. Parker's place on that committee.

The term of Rev. Dr. Noah Porter as Regent having expired, he was re-elected by Congress on March 3 for another term of six years.

ACTING SECRETARY.

In view of the importance of having some one, notably an officer of the Institution, to exercise the functions of Acting Secretary in the event of the extended absence, disability, or death of the Secretary, a law was passed January 24, 1879, giving to the Chancellor the power to make such selection; and Mr. W. J. Rhees, the chief clerk, was appointed to fill the position. The Board at its last meeting found some informality or uncertainty in the act of Congress, and the following act, prepared by Hon. G. F. Edmunds, of the Senate, one of the Regents, was passed, and approved on May 13, 1884:

An act to provide for the appointment of an Acting Secretary of the Smithsonian Institution.

Public, No. 31, Forty-eighth Congress, first session.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Chancellor of the Smith-

*The family name of Davies Gilbert was Giddy. At his marriage, in 1808, he assumed his wife's name, Gilbert.

sonian Institution may, by an instrument in writing filed in the office of the Secretary thereof, designate and appoint a suitable person to act as Secretary of the Institution when there shall be a vacancy in said office, and whenever the Secretary shall be unable from illness, absence, or other cause to perform the duties of his office; and in such case the person so appointed may perform all the duties imposed on the Secretary by law until the vacancy shall be filled or such inability shall cease. The said Chancellor may change such designation and appointment from time to time as the Institution may in his judgment require.

Approved May 13, 1884.

In accordance with this act the following action was taken by the Chancellor:

By virtue of the authority conferred on me by the act of May 13, 1884, "to provide for the appointment of an Acting Secretary of the Smithsonian Institution," I hereby designate and appoint Mr. William J. Rhees to act as Secretary of the Institution when there shall be a vacancy in that office, and whenever the Secretary shall be unable, from illness, absence, or other cause, to perform the duties of his office.

M. R. WAITE,
Chancellor of the Smithsonian Institution.

LYME, CONN., *July* 2, 1884.

PORTRAITS OF THE REGENTS.

It has been the object of the Smithsonian Institution to make a collection, as complete as possible, of the likenesses of all who have served as its Regents. This object is comparatively easy of attainment in the immediate present, but as the enterprise was not initiated until quite recently, there is an undesirable number of blanks in the collection. Crayon portraits, however, of Prof. Asa Gray, at present one of the Regents, and of President Fillmore, and Vice-President George M. Dallas, who were Chancellors of the Institution, all by Mr. Henry Ulke, were added to the gallery during the year.

FINANCES.

As in previous years, the Secretary has much pleasure in announcing the excellent condition of the finances; all indebtedness to the 1st of January, 1885, having been paid, and leaving a balance in the Treasury available for the operations of the coming year. In the report of the Executive Committee will be found a statement of the receipts and expenditures, with the balances, as also a list of appropriations made by Congress. In the list of credits enumerated will be found the sum of $900, appropriated by Congress for expenses of construction and installation of the Henry statue over and above the original appropriation.

The permanent Smithson fund in the Treasury of the United States is $703,000. The receipts during the year 1884, including the balance unexpended on the 1st of January, were $68,994.20, and the expenditures $43,613.36; leaving a balance of $25,380.84, available for the operations of the Institution, in 1885.

BUILDINGS.

Smithsonian Building.—The appropriation of Congress, available on January 1, for the reconstruction of the eastern range and wing was insufficient to complete it, and an additional sum of $15,000 was granted at the first session of the Forty-eighth Congress. This was expended in fitting up the two upper stories of the building, which had been necessarily left unfinished for lack of funds. This included the introduction of iron furring and iron lathing for the ceilings immediately under the roof—a measure very necessary for the comfort of the occupants of the rooms below them. It was impossible, however, to find the means for plastering, which yet remains to be done.

With the additional appropriation many of the rooms were fitted up specially for their requirements, including a post-office, which is used by nearly 200 persons—equal in the amount of mail distributed daily to that of a village of considerable size.

In view of the difficulty of making the electric connections answer a satisfactory purpose, it was thought best to make provision for introducing the pneumatic clock system whenever occasion allowed, and for this purpose the air-tubes were inserted, to which the regulator-clock and the dials in the several rooms can be fitted at any time. A similar provision was made for the oral annunciator—an arrangement by which communication can be established direct at a central station between the pipes leading to any two rooms in the building, thus facilitating communication and obviating the use of several telephones. A few telephones have been introduced, more especially with reference to connection with the switchboard in the National Museum, and by which communication is established with all parts of that building, as well as with the city systems of exchange and those of the Departments.

By the courtesy of the Superintendent of the Observatory, and at but slight expense, a control-clock was set up in the National Museum building, as also in that of the Smithsonian Institution, these being regulated at noon each day by communication direct from the Observatory. In this way the important desideratum of accurate time is obtained.

The rooms in the reconstructed portion of the building are now all occupied for the general purposes of the Institution, notably the departments of administration, of international and miscellaneous exchanges, of the reference library, of transportation, and of publication. Several rooms are occupied by artists employed in connection with the work of the Institution, or persons who are engaged in preparing special reports upon collections and explorations made by them under the direction of the Smithsonian Institution, the Fish Commission, and the United States Signal Office. Three rooms have been fitted up as a special chemical laboratory, in charge of Dr. Kidder, the chemist of the United States Fish Commission; and all work in the way of rating of thermometers, barometers, and hydrometers is under his direction, as also that con-

nected with chemical analyses of air, sea-water, &c. Much work has already been done by him in this connection.

Two rooms are occupied by the United States Coast and Geodetic Survey in making pendulum experiments.

Considerable changes have been made in the central portion of the main building, consequent upon the retransfer of the temporary offices to their permanent quarters in the eastern end. The large room on the first floor has been given up exclusively to the collections of birds, shells, and in small part to the fishes; and by the removal of the cases on the south galleries exceptional facilities have been furnished to the curators who have charge of these departments respectively.

During the year some experiments were made by the Brush Electric Light Company in lighting Washington by means of powerful arc lights placed on top of lofty buildings, the points selected for this purpose being the dome of the Capitol, the summit of the Smithsonian tower, and the top of the Washington Monument. To increase the altitude of the Smithsonian tower a pole was erected 50 feet high, the top of which was, therefore, about 200 feet from the ground. At the request of the Institution, General Hazen, Chief Signal Officer, was kind enough to lend a large vane, which has been erected, and which serves an admirable purpose in showing the direction of the wind from over a wide extent of the city.

National Museum Building.—This building continues to give entire satisfaction as fully carrying out its objects. As might be expected, the ordinary minor repairs have been required from time to time, but nothing involving any considerable expense. Some of the wooden floors have rotted in places, and may hereafter require renewal. At present, however, the renewal of a few of the boards has answered the purpose.

Major Powell, of the United States Geological Survey, having secured, by Congressional favor, the use of a large fire-proof building in this city, his own offices and those of a considerable portion of his scientific aids have been transferred from the National Museum building, permitting a rearrangement in the latter, which has been greatly to the convenience of the service. The rooms vacated in the northeastern pavilion were reoccupied, however, by the chemical and physical departments of the Geological Survey; but the transfer of the latter from the southwestern pavilion has enabled us to give much better accommodations to the mineralogical, metallurgical, and lithological branches of the service. The four courts which have been hitherto used merely as work-rooms or for storage have been cleared out and will soon be occupied by exhibits, thus adding over 16,000 square feet to the available space for display.

Temporary shed in the grounds.—The immense amount of work required to properly comply with the directions of Congress in connection with the exhibitions at Cincinnati, Louisville, and New Orleans made it necessary to take a portion of the appropriation to erect a temporary

building of 100 by 50 feet in the grounds. This, of course, will be removed as soon as it can be dispensed with; but it has furnished an important aid in the general work of the Institution for the year.

Brick work-shop.—The vacating of several rooms by the transfer of Major Powell's photographic department to its new quarters on F street has permitted a much more satisfactory arrangement to be made of the taxidermical service, Mr. Henry Marshall, in charge of the mounting of birds, having moved upstairs and left the lower floor to Mr. Joseph Palmer, the superintendent of the division of modeling in plaster and papier-maché. The building has also been used to unpack a large collection of corals, which was made by Dr. Edward Palmer for exhibition at New Orleans.

Armory Building.—This building has received some necessary repairs to its roof and has been painted inside, so as greatly to increase the neatness of its appearance. The two oval spaces referred to in the preceding report as having been left in the concreting of the yard have now been converted into fish-ponds, in which carp and other fish are kept pending their distribution by the United States Fish Commission.

An extension of the car-shed has also been built, under which four cars of the Fish Commission can be accommodated.

As has already been stated, a side-track from the Baltimore and Potomac depot runs into the grounds of the Armory and under the sheds, and the whole establishment has been of very great service for loading the exhibits prepared by the Smithsonian Institution, the Fish Commission, the Interior Department, the Treasury Department, &c., for the three great expositions already referred to.

Additional Museum Building.—The need of an additional Museum building was fully detailed in the last report, the demand for it being very much greater now than before, in view of the immense additions made by the regular sources of supply. Very many objects of great interest and requiring a large space for their accommodation have been promised by exhibitors at New Orleans, and it is a serious problem to know where these can even be stored, aside from the possibility of properly displaying them. The full details in regard to the necessity of this building will be found in the report of 1883.

Building for the Alcoholic Collections.—The presence of alcoholic specimens in large numbers, so important in a scientific point of view, greatly endangers the safety of museum buildings and their contents, and most of the establishments in Europe have lately taken the precaution to construct separate buildings peculiarly adapted for the purpose. An application was made at the last session of Congress for an appropriation to put up a similar building in the grounds of the Institution, but it was not acted upon favorably. This item has been renewed in the estimates for the coming fiscal year.

MEETINGS OF SCIENTIFIC BODIES.

The Board of Regents, at its meeting in January, 1881, formally tendered the use of the lecture-room and other accommodations in the National Museum to the National Academy of Sciences, and authorized the executive committee to grant a similar courtesy to other national organizations having the advancement of science as their object. Under this arrangement the National Academy met on Tuesday, April 15, and continued in session until Friday, April 18.

In addition to the facilities afforded to the National Academy of Sciences, mentioned above, it was thought quite in accordance with its relationships to the Smithsonian, especially as established since the resolution of the Board, above referred to, to give to the Academy the use of one of the new rooms in the extension of the Smithsonian building for its archives, library, and other property. This has accordingly been done, and two rooms have been assigned for the purpose. It has proved to be a very great convenience to the officers of the Academy, especially during its meetings in the adjacent National Museum building.

Among the most interesting meetings of 1884 in the National Museum, of the national scientific societies, was that of the American Fish Cultural Association, which took place in May, it being the first convocation it has ever held in the city of Washington. In addition to the association itself, invitations were extended to the fish commissioners of nineteen States, and a large attendance was the result. Many papers were presented, but the chief point of attraction was the opening to the public of the fisheries section of the Museum, as arranged after the return of a part of the collection from the International Fisheries Exhibition in London. The Brush-Swan Company kindly put in sufficient plant to illuminate the entire building, especially the fisheries section, and a very large attendance was present on the occasion. The annual address was delivered by Hon. Theodore Lyman, who was followed by Hon. S. S. Cox and others. The meeting was varied by an excursion on the steamer Fish Hawk to the shad-hatching grounds near Fort Washington, where the processes of treating the fish were duly exhibited.

LECTURES.

The success of the course of lectures delivered in 1883, in the lecture-room of the National Museum, under the auspices of the Anthropological and Biological Societies, induced those bodies to establish a second course for 1884, and, as before, these were attended by large audiences.

The list of these lectures will be given under the head of National Museum.

Toner Lectures.—It is known to the Board that an endowment was made by Dr. John M. Toner, of Washington, of a fund, the interest of which was to be appropriated in giving a series of lectures on some subject pertaining to medicine, surgery, or public health; and, by an

arrangement made with my predecessor, these lectures are published at the expense of the Smithsonian Institution, as a portion of the series of Smithsonian Miscellaneous Collections, and in that form distributed to public libraries and to institutions having a common object with the lectures in question.

The lectures delivered have been as follows:

I. On the Structure of Cancerous Tumors and the mode in which adjacent parts are invaded. By Dr. J. J. Woodward. Delivered March 28, 1873. Published November, 1873. 8vo, 42 pp.

II. Dual Character of the Brain. By Dr. C. E. Brown-Séquard. Delivered April 22, 1874. Published January, 1877. 8vo, 23 pp.

III. On Strain and over-action of the Heart. By Dr. J. M. Da Costa. Delivered May 14, 1874. Published August, 1874. 8vo, 30 pp.

IV. A Study of the nature and mechanism of Fever. By Dr. H. C. Wood. Delivered January 20, 1875. Published February, 1875. 8vo, 47 pp.

V. On the Surgical complications and sequels of the continued Fevers. By Dr. William W. Keen. Delivered February 17, 1876. Published March, 1877. 8vo, 70 pp.

VI. Sub-cutaneous Surgery. By Dr. William Adams. Delivered September 13, 1876. Published April, 1877. 8vo, 17 pp.

VII. The Nature of Reparatory Inflammation in Arteries after Ligatures, Acupressure, and Torsion. By Dr. Edward O. Shakespeare. Delivered June 27, 1878. Published March, 1879. 8vo, 70 pp. and 7 plates.

VIII. Suggestions for the Sanitary Drainage of Washington City. By George E. Waring, jr. Delivered May 26, 1880. Published June, 1880. 8vo, 24 pp.

IX. Mental over-work and premature disease among public and professional men. By Dr. Charles K. Mills. Delivered March 19, 1884. Published January, 1885. 8vo, 36 pp.

As it has been found quite impossible to supply gratuitously the large demand from medical men and others for these lectures (in addition to the liberal grant to the leading public libraries and other institutions in this and foreign countries), the uniform price of 25 cents has been fixed for each, by which probably their more equitable distribution will be secured.

The rooms of the National Museum were occupied on March 19 for the delivery of the ninth lecture of the foregoing series by Dr. Charles K. Mills, of Philadelphia. A large and attentive audience was present during the delivery, and the paper will be printed as soon as the revision is received from the author.

ROUTINE WORK IN THE INSTITUTION.

The most important event of the year to be mentioned in this connection is the occupation of the new rooms in the eastern range and

wing of the Smithsonian building after their reconstruction, a work which occupied about a year from its commencement in the spring of 1883.

For many years past the small number of rooms available for the administrative offices of the Institution has greatly impeded its business and interfered with the effectiveness of the work of all the employés. The stock of publications was widely scattered in different parts of the Smithsonian building, and the rooms were overcrowded with clerks and assistants. The records were necessarily kept in places more or less inconvenient of access, with a constant fear of their destruction and that of other property of the Institution by fire in a building so constructed that should a fire break out it would be almost impossible to prevent the combustion of the entire edifice. Thanks to the liberality of Congress in furnishing the necessary means, these inconveniences and dangers are all things of the past; the offices have been re-arranged, everything brought together in convenient approximation, and every necessary provision made for the comfort of the employés and the efficiency of their work.

The Secretary transferred his office from his temporary quarters in the National Museum building early in May, and a few days after the chief clerk, corresponding clerk, and others moved from their improvised rooms in the lower hall of the Institution. By the end of the year the work was finished and everything in good running order.

The *personnel* of the Institution continues to be the same as heretofore, apart from the addition of one or two subordinate employés required to meet the increase of work.

CORRESPONDENCE.

This continues to increase in about the usual ratio, and represents a very large part of the operations of the Institution. The range of subjects presented for consideration covers every branch of speculation and of human knowledge; and there are very few subjects upon which the advice and opinion of the Institution are not asked. In accordance with its uniform rule, all communications are treated with respect; and where the information asked for cannot be furnished directly, the letter is referred to some expert.

EXPLORATIONS.

From the very beginning of its work a large part of the attention of the Institution has been directed towards increasing our knowledge of the physical condition and natural history of various parts of the globe, especially on the continent of America, and almost every report contains some account of work accomplished in this direction. No single agency has done as much as the Smithsonian Institution in developing a knowledge of the region in question, whether as the result of observa-

tions prosecuted entirely or partly at its own expense, or made at its suggestion by Government expeditions and private parties. An extensive correspondence and more or less intimate association with men of science resident in the different localities has also been utilized to suggest points of inquiry and invite the communication of information.

The year 1884 has been no exception to the statement just made. Indeed, it is doubtful whether any of its predecessors has exceeded it in the amount of results obtained. This is, of course, largely due, as in many previous years, to the co-operation of the United States Signal Service, under General Hazen; the United States Geological Survey and the Bureau of Ethnology, under Major Powell; and the United States Fish Commission.

As heretofore, I shall give in geographical sequence a short account of the various expeditions and of their results, leaving the full account of the collections themselves to be reported upon by Mr. Goode, the Assistant Director of the National Museum.

Greenland.—The most interesting chapter of the exploration of Greenland is that connected with the history of the Greely Relief Expedition, which was fitted up by provision of Congress for the purpose of rescuing Lieutenant Greely and his fellow members of the Signal Service from their imprisonment in the Polar Seas. After the two futile attempts, made in 1882 and 1883, to communicate with the International Arctic station at Lady Franklin Bay, and to relieve Lieutenant Greely and his command, a new expedition was organized by a special act of Congress, at an early date in 1884, under the direction of the Secretary of the Navy, and Secretary of War. Subsequently the Dundee whaler "Thetis" and the "Bear" of the Newfoundland sealing fleet, two stout steamers of 600 and 609 tons burden, were purchased by the Government, and taken to the Brooklyn navy-yard to be overhauled and refitted. The English Government generously presented the steamer "Alert," one of the vessels of the late Arctic expedition under Captain George Nares, to be used in the search, and the collier "Loch Garry" was chartered to act as tender. The expedition was placed under the command of Commander W. S. Schley, U. S. N., who selected the "Thetis" as flag-ship, and under whose superintendence the squadron was thoroughly fitted out.

On April 23 the "Bear" left the United States bound for St. John's, Newfoundland, followed by the "Thetis" on May 1, and by the "Alert" on the 10th of the same month. The "Thetis" arrived at Disco on May 22, accompanied by the "Loch Garry," where she learned that the "Bear," having reached that port on the 15th, had left the day previous, to continue to Upernavik. Convoying the "Loch Garry," the flag-ship sailed again from Disco on the 24th, touching five days later at Upernavik, where she met her consort. In the afternoon all the whalers which had gathered there left with the "Thetis" and "Bear," the tender remaining behind to await the convoy of the "Alert"

and a more favorable time for crossing Melville Bay, which was full of heavy ice. The time between June 6th and 11th was spent at the Duck Islands, looking in vain for an opening in the pack. Taking advantage of every narrow lead the vessels fought their way through the ice, now resorting to ramming and torpedoes to force a passage, then tying up to the lee of a berg or to a heavy floe. By dint of labor they finally came in sight of Cape York, but it was impossible to get into open water before the 18th. Accompanied by two of the whalers they then steamed on. The "Bear" was signaled to push ahead and send a party on shore to communicate with the natives. Nothing had been heard here of Greely. Every place was searched where records or people were likely to be found. The "Bear" went to the Cary Islands, the "Thetis" to Conical Rock, Wolstenholme and Saunders Island, to Cape Parry, and finally to Littleton Island, where a cache was found, but no tidings of the party. Now the impression became general that the vessels would have to proceed to Lady Franklin Bay. Letters were got ready to be sent home by the "Alert," when she should return in the autumn, and on the 22d, 720 rations were cached. When the "Bear" arrived at noon it was decided to land 3,000 rations more at Payer Harbor, and both vessels stood across through open water to Cape Sabine, where Greely and the survivors of his command were found in a starving condition. On July 17, the vessels, with the exception of the "Alert," were at anchor again at St. John's, Newfoundland.

Considering that the whole energy of the squadron had to be devoted to the rescue of the Lady Franklin Bay party, the natural history collections, made by the officers on various occasions, are richer than might have been expected; the numerous photographs of the country, of the natives, and the ice, in its various shapes and formations, will be of lasting value.

The physical observations during the course of the expedition were made part of the regular routine of the vessels. The natural history work, however, was prosecuted by the naval ensigns who had been sent by the Navy Department to the Smithsonian Institution specially for the purpose of being trained for such duty. Among these were Messrs. C. A. Harlow, A. A. Ackerman, and C. S. McClain. These gentlemen had all been well trained at the Institution in the methods of instantaneous photography, in taxidermy, and in the collecting of minerals and fossils; and although the time occupied by the expedition—thanks to the energy of its commander, Captain Schley, and his associates—was very much less than had been anticipated, very interesting and desirable collections were made by the gentlemen mentioned.

The landings were made, for the most part, at Disco, Upernavik, Duck Island, Conical Rock, Camp Clay, &c., and the gatherings consisted of rock specimens, minerals, fossils, numerous birds, and an acceptable collection of fishes and marine invertebrates in alcohol. The photographic plates have not yet been developed, but will no doubt

show much of very great interest. These gentlemen all make acknowledgment of the assistance given them in their work by the orders and hearty good feeling of Captain Schley and the other officers in command.

The Greely Relief Expedition fully and entirely carried out its mission of restoring the survivors of the Greely party to their friends in the United States. By far the greater part, however, of the apparatus and collections made in the several years of absence was left behind at Fort Conger, and may never be recovered. A few specimens were brought home by Lieutenant Greely, but have not been received at the National Museum.

Labrador.—The reports of 1882 and 1883 give full details of the work prosecuted by Mr. L. M. Turner at Fort Chimo, Ungava Bay, in Northern Labrador, and full credit given to the Chief Signal Officer for his encouragement to Mr. Turner to make collections of specimens in the intervals of his duties of recording the meteorological and other physical phenomena of the region. Mr. Turner's two years of detail expiring in 1884, he returned to Washington and is now engaged in preparing his report. In order to make the report complete, I subjoin a brief extract prepared by him of his work during the two years:

"Under letter of instructions of date of May 27, 1882, from the Chief Signal Office, United States Army, I departed from Washington June 1, 1882, for Montreal, where I remained until June 7th, and joined the Hudson Bay Company's schooner 'Tropic' at Quebec, and left there June 8th for Rigolet, Labrador, where we arrived June 28th. At this place I remained until July 8th, and proceeded on the company's steamer 'Labrador' for Davis' Inlet, Labrador, where we arrived July 16th, and remained four days. At these two stations I collected a great number of fishes, birds, plants, and insects. On the 21st of July we started for Nakvak, Labrador, but were prevented by bad weather from entering that fiord, and continued around Cape Chidley, at the entrance of Hudson Strait. After entering we immediately encountered heavy ice, and were detained eleven days in Ungava Bay. We went on shore for part of one day (July 31st) at the mouth of George's River emptying into that bay. On the 6th of August we ascended the Koksoak or South River, and anchored at Fort Chimo, Ungava district of the Hudson Bay Company, where I was to establish a meteorological observation station for the Signal Service. The meteorological observations were to be five in number daily at the following times: 7.35 A. M.; 11.35 A. M.; 3.35 P. M.; 7.35 P. M., and 11.35 P. M. A dwelling not being ready for occupation, I was necessitated to await the completion of a building intended for a blacksmith shop, which when finished was used by me as dwelling and office until my final departure from Fort Chimo. During my stay at Fort Chimo I had an opportunity to ascend the Koksoak River to the 'Forks' (junction of the North or Larch River with the Koksoak and about 105 miles from the mouth of the latter river). Also to the Falls, some 30 miles above the 'Forks.' These 'Falls' were visited for the purpose of photographing them. I again visited the 'Forks' for the purpose of obtaining winter resident birds, and while on this trip I ascended the Larch or North River, and discovered a small river flowing from the southwest into it. On this river, some 14

miles from its mouth, is a small falls of some 25 feet perpendicular, affording one of the most picturesque scenes I ever viewed. On another occasion I visited Whale River, to the east of the Koksoak about 50 miles, and on this trip passed the mouth of 'False' River, so named because it is nothing but a *cul de sac* of about 40 miles length and running nearly parallel with the Koksoak. The tides exert such influence on these rivers that navigation is extremely dangerous. The rise and fall of the tides at the mouth of the Koksoak were determined by me to be sixty-two feet and three inches.'

"On the 4th of September, 1884, I left Fort Chimo, Ungava, on the Hudson Bay Company's steamer 'Labrador,' to return to civilization. We stopped for ten days at George's River, Ungava district, to re-establish a trading station there for the Hudson's Bay Company, leaving there on the 14th for Nakvak, Labrador, where we arrived on the 16th, and left next day for Davis Inlet, where we arrived on the 19th and remained until the 23d. We then started for Rigolet, Labrador, and arrived there on the 25th, and left next day on the Newfoundland mail steamer 'Hercules' for Battle Harbor, Labrador, where we arrived October 1, leaving next day for St. John's, Newfoundland, on the mail steamer 'Plover,' where we arrived October 6. While on these two mail steamers we stopped at over one hundred fishing stations along the Labrador and Newfoundland coast to call for and deliver mail. On the 16th I left St. John's for Halifax, where I arrived on the 18th, and took railway for Montreal, and arrived there on the 21st, and left next day for Washington, where I arrived on the 23d. My leisure time was employed at every locality visited, in collecting specimens of natural history. The results are given approximately as below in round numbers:

"Of birds, 1,800 specimens; eggs, 1,800 specimens; fishes, 1,000 specimens; mammals, 200 specimens; ethnological, 600 articles; plants, a great number; insects, over 200,000; geological specimens, a great variety; Eskimo linguistics, over 500 pages of manuscript, embracing thousands of words and over 800 sentences, which were obtained during the winter nights and at other times when outdoor work could not be done.

"To this should be added twenty-three months of continuous meteorological observations, taken and recorded at Fort Chimo, Ungava, which have been already turned over to the Chief Signal Officer, United States Army.

"To enable me to successfully prosecute these labors, I was by the characteristic liberality of the Secretary of the Smithsonian Institution abundantly supplied with all necessary articles for procuring, preserving, and transmitting the results."

Reference was made in a preceding report to the work accomplished by Dr. C. Hart Merriam in the investigation of the natural history of the seals of the coast of Labrador. The arrangements made by Dr. Merriam during his abode in Newfoundland and Labrador have furnished him additional material during the present year, the results of which he has kindly shared with the National Museum in the way of skins and skeletons of several species of seals.

Arctic Coast.—Although we are unable to record quite so large acquisitions from the Arctic coast as were obtained in the year 1882 from

the Point Barrow Expedition of the Signal Service Bureau, under cor mand of Lieutenant Ray, yet some interesting contributions have bee received. Captain Healy and officers of the revenue steamer Corwi have supplied collections from Hotham Inlet and other points alon the coast, including numerous minerals, birds, fish, invertebrates, &

The following summary of Captain Healy's work has been furnishe through the Secretary of the Treasury, Hon. Hugh McCulloch:

"Captain Healy has, during the past season, visited with his con mand the new volcano on Bogoslov Island, of the Aleutian chain, i longitude 168° W., which, after some years of quiet, recently becam active. He caused a survey of the island to be made by two of h officers, who submitted a very interesting and valuable report, contai ing a detailed description of the large accession to the island throw up by the recent volcanic action, and through the aid of another office of the vessel obtained some excellent photographs of the volcano in i various aspects. Later in the season Captain Healy sent a boat exped tion up the Kowak River, which debouches through its delta into H tham Inlet, Kotzebue Sound. Lieutenant Cantwell, who conducted thi expedition, ascended the Kowak River a distance of 379 miles. H submitted a report, showing a careful survey of the river for the di tance named, and a very interesting discovery in a large deposit c jade (nephrite) situated in a mountain (named in the native languag Ashoganok, meaning smooth stone,) lying a few miles north of the rive Also a description of the flora and fauna of the river's banks, accom panied with specimens. Assistant Engineer McLenegan, who accom panied him, submitted also a valuable list of birds of Northern Alask with descriptions and specimens. Lieutenant Cantwell made a fu ther detailed survey of Selaivrk Lake, tributary to the same inlet, ac companied with a well-executed chart of the region. This expeditio brings back the report that the precious metals are found in larg quantities among the high mountains which form the water-shed for th Kowak, Kuryukuk, and perhaps Colville Rivers."

Lieut. George M. Stoney, U. S. N., of the schooner "Ounalaska," wh had visited Arctic America and explored Hotham Inlet and the river entering into it, obtained an interesting series of rocks from the volcan in Behring's Sea. The collections made by him have not, however, ye come to hand.

Both Captain Healy and Lieutenant Stoney have furnished specimen of the crude jade, or jade-like material so much used by the natives o Arctic America for ornaments and weapons.

The Pacific Steam Whaling Company established during the year a depot at Cape Lisburne, with Mr. D. Woolfe in command, for the pur pose of mining coal for the use of the whalers, and specimens of thi coal and of the associated fossils have been furnished by Mr. Woolfe Miscellaneous collections of the natural history of the region are ex pected from that gentleman during the year 1885.

The North Pacific.—Reference was made in a previous report to the very important work accomplished by Dr. L. Stejneger, under the direc tion of the Signal Office and the Smithsonian Institution, in Kamtschatka and the adjacent group of the Commander Islands. Through the cour-

tesy of Governor Grebnitski, in command of these islands, a number of additional collections were received.

Dr. Stejneger also received from Captain Hunter some skins and skeletons of the mountain sheep of Kamtschatka, filling an important desideratum.

Alaska.—As in previous years, the additions to our knowledge of the natural history and ethnology of Alaska have been very considerable, owing to the continuation of explorations of the different parts of that extensive Territory. The station of the Signal Service at Nushagak, on Bristol Bay, which was so well worked up by Mr. C. L. McKay, was subsequently re-established after his death by drowning, by Mr. J. W. Johnson, from whom a collection of birds was lately received, which was specially noteworthy as containing specimens of the Alaska willow wren and of the yellow wagtail, representing a locality many hundreds of miles further south than St. Michael's, the place of previous record.

Lieut. T. Dix Bolles, on board the U. S. S. "Adams," during its period of service at Sitka, used all opportunities in his power to enrich the National Museum by his contributions, and became so much interested in his work that he sought and obtained a transfer, through the favor of the Navy Department, to the steamer "Pinta," which replaced the "Adams" during the past summer. At latest advices he was still engaged in his scientific work.

Mr. John J. McLean, of the Signal Service, stationed at Sitka, has secured many ethnological objects of great rarity.

Mr. W. J. Fischer, who is stationed by the Coast Survey at Kodiak, has used many opportunities both there and in the adjacent regions to continue his important work; this, including much information in regard to the manners and characteristics of the native tribes.

From the Rev. J. Loomis Gould a collection of Indian carvings and other articles of ethnology were obtained, representing some quite new forms of aboriginal construction.

British Columbia and Washington Territory.—For the purpose of increasing material for the needs of the National Museum and its representation at the New Orleans Exposition, the services of Mr. James G. Swan, of Port Townsend, were secured to visit various parts of Alaska and British Columbia. His collections, as received so far, have been, as usual, very interesting and important. During a visit to Victoria in the interest of this service, he was invited to deliver a lecture before the legislature upon his observations made in 1883 in Queen Charlotte Islands, and having obtained permission from the Institution for the purpose, he complied with the request.

The specialties of Mr. Swan's collection consist of very full illustrations of the whaling apparatus and outfit, including boats, &c., used by the Haidah Indians.

A valuable monograph by Mr. Swan, upon the ethnology of the Haidah Indians, which had been contributed to the Treasury Department, was transmitted by its Secretary for publication in the reports of the Bureau of Ethnology.

Oregon and California.—From Oregon the most noteworthy collections are those furnished by Capt. Charles Bendire, at Fort Klamath, to whose important contributions and services to the Fish Commission full detailed reference is made in another part of the report.

The returns from California consist in large part of numerous collections of shells, minerals, fossils, and archæological objects from Mr. R. E. C. Stearns, recently appointed as Curator of Conchology in the National Museum. In transferring his effects from San Francisco to Washington he brought with him a very large series of specimens, of which he has made a present to the National Museum.

Other specimens are birds from Mr. L. Belding, and fossils from Mr. C. R. Orcutt.

Mr. Charles H. Townsend, connected with the fishery establishment at Baird, Shasta County, California, has made and supplied the most extensive series of collections of mammals ever received from the State of California, all in most admirable preservation and specially adapted for mounting. The collection also embraces numerous skins, skeletons, and skulls of the various sea lions and seals from the Farralone Islands, and an additional collection of sea elephants from South California is now on its way. In addition to this there are a large number of skins of birds, fossils, and other objects of interest.

Arizona and New Mexico.—These Territories have been particularly well represented during the year; the former by the large number of skins of mammals, birds, and other objects of interest furnished by Mr. E. W. Nelson; the latter by an enormous collection of modern Indian pottery and other articles, which, when packed, represented a bulk of many thousand cubic feet. These collections made under the auspices of the Bureau of Ethnology, and others obtained by Mr. James Stevenson under similar direction, may be considered as exhausting all possible demand for such articles from the region in question, and, in fact, represent a series that can never be duplicated. The articles obtained represent for the most part nearly all those that have been used by the Indians for many years. All others now procurable are of more modern make, and in large part fabricated to meet the demands of travellers along the routes of the new lines of railways, and being made especially in great haste for sale, are very inferior both in material and decoration.

Some contributions to the fauna of New Mexico were supplied by Dr. R. W. Shufeldt, of the Army, from his station at Fort Wingate.

Mr. E. W. Nelson has furnished the following account of his explorations and collections in Arizona during 1884:

"When I reached Tucson in January, 1884, it was midwinter, but the only evidence of the fact there, lay in the leafless vegetation and the frosty nights. Thin ice formed quite frequently on the borders of stagnant pools. The days were warm and pleasant, as a rule, much like the 'Indian-summer' days of autumn in the eastern States.

"Prairie dogs and other mammals, that hibernate during winter in more northern latitudes, are found full of activity at all seasons in this portion of Arizona.

"Tucson is situated on a large basin-like plain with groups of mountains on every side, from 10 to 30 or 40 miles distant. It is also located near the eastern border of the region covered by the giant cactus, with several species of birds having their range within about the same limits.

"Various other species of cactus abound, and, with the mesquite woods and the cottonwoods and elder trees along the bottoms near the streams, form the most conspicuous part of the vegetation. The general aspect of the country surrounding Tucson is very desert-like, although covered with scrubby and thorny bushes, yet it is a favorite resort for birds, and is probably the richest field for the ornithologist north of the Mexican border.

"During the four months following my arrival at Tucson, my attention was given to securing a series of the birds found there, with gratifying success. Perhaps the most notable of the captures consisted of a fine series of the resident race of song sparrow, by the aid of which Mr. Henshaw was enabled to decide that the song sparrow of Southern Arizona is a resident form peculiar to that region, and to which properly appertains the name of *Melospiza fasciata fallax;* while the song sparrow of the Rocky Mountain region in general, which has heretofore been known as *fallax*, was in reality an undescribed form to which Mr. Henshaw has given the name of *Melospiza fasciata montana.*

"A series of the rare *Harporhynchus bendirei* was also taken, including the young in first plumage.

"It having been discovered that the deserted holes of *Colaptes chrysoides* and *Centurus uropygialis* in the trunks of the giant cactus were resorted to by the little-known Wh tney's owl (*Microthene Whitneyi*) and the southern screech owl (*Scops trichopsis*), a number of these birds were captured by cutting down the cactus stems and taking the birds from their holes.

"Later in the season, during the last of May, a portable ladder some eighteen feet long was used to good purpose in securing the birds and their eggs. The giant cactus is frequently from thirty to forty feet high in that vicinity, and the old woodpecker holes are placed so high that one had very often to stand on the extreme upper end of the ladder with one arm embracing the thorny cactus and the other hand employed in cutting out the entrance of the hole to admit the hand. This style of work is very successful, and, although two men are required to do it, one can count upon finding an owl in about every fourth or fifth hole examined in a good locality. The same proportion holds good when hunting eggs in the nesting season. The vicinity of streams is the most productive field. Toward the end of May the heat became very oppressive, and early in June I made camp on the eastern slope of the Santa Rita Mountains, about sixty miles southeast of Tucson. My camp was in the live-oak belt at about 5,000 feet above the sea-level. Here I found a much cooler temperature and a number of birds not seen before. The breeding season was nearly over, though I was fortunate enough to secure a fine nest and set of eggs of the black-throated gray

warbler (*Dendrœca nigrescens*). Fine series of the Arizona jay (*Cy nocitta sordida*), the Strickland's woodpecker (*Picus stricklandi*), La· rence's flycatcher (*Myiarchus lawrencei*), and of other species of great or less rarity were secured here.

"The Scott's oriole (*Icterus parisorum*) was found rather common bı extremely shy there, and a number of skins were taken. Above tl oak belt on this small group of mountains is a sparsely timbered be of pines reaching to the summit, at about 10,000 feet altitude. Tl deer, bears, and peccaries, or 'musk-hogs,' as they are called locall were once very numerous in these mountains, but the occupation every permanent spring or creek by ranchmen, and the presence c prospectors at all seasons, has nearly driven the game from these hill

"The vicinity of my camp, near Gardiner's ranch, is probably tl very best location for a collector that these mountains afford and is rich field for the ornithologist. From this camp, in company with tw friends, an excursion was made toward the Mexican border into a lo bottom. This bottom is heavily wooded with cottonwoods and othe trees and is a notoriously malarial region. It is full of birds, but wh ever ventures there to do any extended work must be ague-proof. I this bottom the blue grosbeak was very common, as many as fifteen c twenty being seen on some days. At the head of this valley, in th open grassy flats, the Arizona sparrow (*Peucœa arizona*) was very abunc ant, and its sweet song was heard from morning till night.

"The middle of July I broke camp and moved about twenty-five mile southeast to Camp Huachuca, at the base of the Huachuca Mountains Very little was done here, as the mountains and their faunas were ver similar, and nothing, not taken before, was seen. Both the Santa Rit and Huachuca Mountains are poorly watered; and although special at tention was not given to hunting for ruins or other evidences of ancien occupation by Indians, yet nothing of the kind having been found in m tramps after birds would indicate a paucity of such remains; nor coul the prospectors familiar with these mountains name any such ruins In August I returned to Tucson for a few days and made a flying visi to the Papago Indian Reservation, nine miles south of town, at the ol mission of San Xavier. There I secured samples of their pottery anc other of their manufactures, such as the few natives present could b induced to part with. These natives make the large porous water-jar with which every house is supplied in Southern Arizona. The womer mix the clay with horse-dung and then mold it up by hand into th tall, gracefully-shaped jars, smoothing it on the surface with a smal wooden trowel. The pot is then baked in a hot fire, and the parti cles of dung being burned out, the requisite porosity is obtained. When filled with water the fluid oozes slowly through the sides and bottom of the jar, and if kept in a shaded spot the rapid evaporation from the surface keeps the water inside cool and palatable in the hottest weather. This jar is almost a necessity in every household in the hot southern region where ice is almost unknown. The Papagoes of San Xavier derive a considerable income from the sale of these jars. The women hawk them about the streets of Tucson and sell them for twenty-five cents each. This is certainly not an exorbitant price for a jar that will hold from five to ten gallons, and which the seller has packed nine miles, upon her back, into town.

"The intensely hot weather caused me to leave Tucson after a very short stay there, and the 20th of August found me located at Springerville, at the eastern base of the White Mountains, and at an altitude of about 6,500 feet. The change from the arid, sun-baked plains of the

southern part of the Territory to the green hills and magnificent pine forests of this vicinity was a marked and welcome one. The temperature here at that time was also cool and very pleasant. For several weeks after my arrival here my health was unusually poor, owing to the debilitating effect of the heat experienced earlier in the season, but recovering from this, I passed the remainder of the fall in making hunting excursions in various directions from Springerville as a center, for the purpose of securing a series of deer and antelope skins for the National Museum.

"Although the mountains about here have been noted for the abundance of large game in them during past years, yet all kinds of large game were remarkably scarce during the past season. Such being the case, it required much longer hunting and more work to secure the desired game than had been anticipated.

"Bear were not to be found at all, and elk were so scarce that only a single fresh track was seen during several weeks in the woods. Although the cattlemen have invaded this district in force, yet they have only touched the pine country at widely separated places, and I am unable to account for the scarcity of large game.

"The mountains of this range are well watered by creeks and springs, and from 6,500 feet altitude up to timber line they are covered with a fine growth of pines, with aspens, and other trees common to high altitudes in this region, intermingled on the higher ridges. There is scarcely any undergrowth but a dense mat of grass and flowers in these forests, and beautiful mountain parks are found at frequent intervals. These parks vary in size from the tiny glades a few yards across to broad savannas miles in extent, and the country would appear to be a sportsman's paradise were not the game unaccountably absent.

"While at Springerville some time was devoted to examining various old ruins in the vicinity, along the valley of the Little Colorado River. The sites of old stone-walled houses, frequently showing the outlines of several rooms, are common, but only fragments of broken pottery, with an occasional mortar, are found lying about them. Two rooms were cleaned out in one ruin, but the results were discouragingly meager, as only a bone awl, a hammer-stone, and a shell ornament rewarded two days' hard work.

"Along the base of the lava bluffs bordering the valley occur masses of huge, angular blocks of lava, lying as they fell from the cliff in rough masses, and among which are large crevices, frequently leading into irregular chambers and sheltered nooks among the rocks. In these were found much broken pottery, and by careful search nearly all the fragments of several pots were secured. Some old bows, arrows, and other sticks, with the paint still bright upon them, were found in dry spots.

"An old cave in the sandstone on the river, about 15 miles below Springerville, yielded an old pot, some reeds prepared for arrows, a war club, and some spear and arrow-tips. This cave had a great mass of bows and arrows stored in it, when found by the Mexicans some years ago; but the finders fired the pile, and nearly everything was reduced to ashes. Another cave, located about thirty-five miles west of Springerville, is a long, forked passage in the lava rock at the far end of which the discoverers secured a fine lot of pottery a couple of years ago. At the time of my visit nothing remained except traces of a fire where the pottery had been found. The bottom of the cave is covered with a layer of fine clay, such as the pottery was made from.

"From the boy who found the cave I secured a few pot-covers and other specimens, which he took from the cave after his first find.

"The season's work has resulted in a collection of over fifty skins and skulls of mammals, eighteen of which are of deer and antelope; over one thousand bird skins, and eighty birds' eggs; about one hundred and fifty ethnological specimens, and some alcoholic specimens of fishes and mammals."

Eastern Portion of the United States.—Very large numbers of collections from the eastern portion of the United States have also been received, but as having less relation to additions to our knowledge of the natural history and ethnology of the region, they are less noteworthy in the present portion of the report. I should, however, especially mention the exploration of the fresh-water fish fauna of the Mississippi Valley made by Professors Jordan and Gilbert in behalf of the New Orleans International Exposition. As a specially desirable presentation on that occasion, it was determined to show as fully as possible the fishery resources of the region at the outlet of which New Orleans is situated, and to furnish, if possible, every kind of fish known to inhabit the waters of the great river. Several months were occupied in this service, and many hundreds of species obtained and prepared for exhibition. With a somewhat similar object Dr. Palmer was detailed for service in Florida with special reference to securing collections of the corals of the Florida Keys and the Tortugas. Henry Hemphill also assisted in making collections of the invertebrates of Florida.

The display made under the auspices of the National Museum at New Orleans of the economical and attractive natural history of the Gulf of Mexico and the Mississippi Valley were in great part made especially for the occasion, and will constitute a noteworthy feature in the history of American science.

As usual, the collections made under the auspices of the United States Fish Commission along the eastern coast of the United States have been noteworthy in value and extent, resulting from the continual research at the station at Wood's Holl, and especially from the labors of the Fish Commission steamer "Albatross" in the deep waters off the coast. Here, as in previous years, the occasion has been taken to secure large numbers of duplicate specimens for distribution, as educational material, to colleges and academies.

A subsidiary research of the Fish Commission in this connection was accomplished by sending Dr. T. H. Bean to Long Island to explore the adjacent waters, especially those of the Great South Bay, and this resulted in making some discoveries of scientific interest as well as of practical importance.

The West Indies.—Many important contributions to our knowledge of these regions have been made during the year, the most noteworthy being the gatherings in the Caribbean Sea and the adjacent islands, made by the Fish Commission steamer "Albatross," which was detailed

to the service of the Navy Department at its request. The vessel was also engaged in making soundings between the south side of the West Indies and the north coast of South America, resulting in determining the character of the sea bottom with great precision and establishing the existence of a number of unexpected reefs and shoals of great depths, which have been indicated in a model of the bottom of the Caribbean, made by direction of Captain Bartlett, of the Hydrographic Office of the Navy. General collections were made of the land fauna as well as of the marine, resulting in the addition of a very great number of species to the National Museum, of which a noted proportion are of scientific interest. Among these may be mentioned eight new species of birds found on the islands of Curaçoa and Old Providence.

Professor Poey has continued his contributions of fishes from Cuba, and has, in all, supplied a noteworthy proportion of the hundreds of species known to occur in the vicinity of that island.

Dr. Nichols, of Dominica, has continued his donations of birds, mollusks, &c., while from Mr. Morris, director of the public gardens and plantations in Jamaica, many samples of valuable fibers have been secured.

Mexico and Central America.—Professor Alfred Dugés, of Guanajuato, Mexico, has continued his transmissions of objects of natural history, among them being some rare species of birds, &c. Mr. McLeod, of Jesus Maria, in Mexico, has also furnished some rare birds.

As an ethnological contribution, Mr. Romero, the Mexican minister, supplied a series of the playing cards and other gambling implements of the Mexican Indians.

The services of Mr. Aymé, late consul at Merida, were secured to prosecute some investigations into the ethnology of Yucatan and Western Mexico, especially with a view of showing the relationships between the habits and manufactures of the Indians of those regions and those of the southern portion of the United States. Several large collections have already been received from him, and others of still greater moment are on the way.

Other collections, especially of birds, from Yucatan have been furnished by Mr. Gaumer.

On the occasion of establishing the boundary line between Guatemala and Mexico, the services of Prof. Miles Rock, of the Washington Observatory, as astronomer, were secured by Guatemala, and he was provided with a photographic apparatus, furnished by the Smithsonian Institution, and many interesting views of scenery were obtained and forwarded to the Institution.

Among the least known portions of Central America is the region along the eastern coast of Honduras and the adjacent islands, and the offer of Mr. Allstrom, an American engaged in mining researches in that country, to make collections of natural history, &c., was gladly accepted. No returns, however, have yet been received from him.

In addition to the articles already mentioned, a valuable series of the illustrations of the animal and vegetable kingdoms of Guatemala and Salvador were secured from the Government commissioners of those countries to the foreign exhibition held in Boston in the autumn of 1883. These, with similar collections under similar auspices obtained from Venezuela and Brazil, were packed up in the early part of the year 1884, under the immediate direction of one of the employés of the National Museum, and transferred to the National Museum at Washington, where they will constitute an important addition to the collection.

Costa Rica.—As in previous years, Costa Rica has been well represented by the contributions of Mr. J. C. Zeledon, for many years in the service of the National Museum, his transmissions consisting of specimens of medicinal plants, of birds, of vertebrated animals, and of ethnology. Through his courtesy the National Museum is enriched with an almost complete representation of the mammal and bird fauna of that country.

Mr. R. Iglesias, of Chiriqui, has contributed some antiquities and modern pottery.

Reference was made in the last report to the large collection of antiquities, especially of sepulchral pottery, obtained in Chiriqui by Mr. J. A. McNeil, and secured through Messrs. Lamson & Bros., of New York. An additional collection was made during the year under the same auspices.

Nicaragua.—Among the most interesting and least known portions of Nicaragua is the central region, between the Upper San Juan and Lake Nicaragua. A short sojourn there has furnished to Mr. C. C. Nutting quite a number of new species of birds. Mr. Nutting's success induced Dr. Walter Van Fleet to arrange for an expedition to that region under the patronage of the Smithsonian Institution. Duly provided with letters from the Institution, and with certain arrangements for facilitating his work, Dr. Van Fleet proceeded to Aspinwall; but while waiting the arrival of the steamer from Greytown he was taken ill, and obliged to return to his home in Pennsylvania. He hopes, however, at an early date to renew the experiment.

South America.—Interesting collections representing the natural products of the animal and vegetable kingdoms of Venezuela and Brazil were secured from the Governments of Venezuela and Brazil. Dr. William H. Jones, surgeon on the naval vessel stationed on the west coast of Guiana, has contributed some extremely important collections of the antiquities and natural history of the coast of Peru and Chili, and to some extent of the Galapagos Islands. Many of the antiquities are of unusual forms are of great rarity.

Mr. Kiefer, of Lima, has also made similar contributions.

Professor Nation, an eminent naturalist of Peru, has sent some types of rare and undescribed species of birds of that country.

Dr. William N. Crawford, of the U. S. S. "Shenandoah," has also contributed some rare shells from the west coast of Terra del Fuego and the Straits of Magellan.

Europe.—Large numbers of articles, both in single and collective series, have been received from Europe, but as being derived from public museums and not having any specially geographical significance, are not mentioned here, but will be enumerated in detail in the report of the Assistant Director of the National Museum.

It may, however, be well to refer to the arrangement made with Mr. J. Gwyn Jeffries, of London, by which his magnificent collection of recent and fossil shells of Europe has been acquired by the National Museum and in large part received by it, several boxes of specimens coming to hand during the year 1884. This is by far the most valuable private collection of European shells in existence, and especially important in possessing so many types of the deep-sea species dredged in the North Atlantic, and of great value for the determination of the collections of the United States Fish Commission.

Among contributors to the European collections may be mentioned the Royal College of Surgeons, the South Kensington Museum, the British Museum, the Royal Botanical Gardens at Kew, in England; the Museums of Berlin and Dresden, in Germany; of Copenhagen, in Denmark; of Bergen, in Norway, &c.

Asia.—The collections from Asia have been of unusual significance and importance. Reference has already been made to the accessions from Kamtchatka and the Commander Islands as having been obtained through the efforts of Dr. Stejneger, whose personal collections in those countries were dwelt upon in the last report.

Mr. P. L. Jouy, a former employé of the National Museum, and resident for a number of years in Japan, continued his researches in that country, and has supplied a large number of species of mammals and birds of that region, together with other species of animals. The collection of birds being taken in connection with a series presented by Mr. Thomas Blackiston, who spent many years in Japan, gives to the National Museum one of the most complete collections of Japanese birds in existence, and one great in value in view of their relationships to the birds of Western North America. Mr. Jouy has since transferred the field of his researches to Corea, although none of his collections have so far come to hand.

Rev. C. H. A. Dall has furnished some samples of fibers and other native products of the Indian, and the greater part of the exhibit of the Foreign Exhibition in Boston made by Ceylon; while a very valuable collection of musical instruments of East India, and other objects representing a high money value, were contributed by the Rajah of Tagore.

Africa.—This country is represented by a few objects of art and industry, while from New Guinea the collection of weapons, implements, &c., obtained from Mr. A. P. Goodwin, has added very greatly to our representation of that little known island.

Madagascar.—Much attention has been directed to explorations in Madagascar. Lieut. M. A. Shufeldt, of the Navy, left Norfolk a year or two ago on the "Enterprise," and was enabled to leave the ship and spend some time in Madagascar. On this occasion he made a large number of photographic negatives, which were sent to the Smithsonian Institution for development, a set of the prints having been presented to the National Museum. These contained most interesting illustrations of the life, customs, and physiognomy of the people, as well as of the scenery which they inhabit.

The Sandwich Islands.—The greater part of the exhibit made by the Hawaiian Government at the Boston Foreign Exhibition was secured and transferred to the National Museum. These, with the many specimens brought home by the Wilkes expedition in its famous cruise, render the representation of that country very full and complete.

PUBLICATIONS.

Not much has been done during the year in the printing and distribution of special publications by the Smithsonian Institution, although the activity of the National Museum in this respect has been very great. It is expected, however, that during the year 1885, quite a number of volumes will be printed and issued to institutions and libraries in correspondence with it; these to appear in one or other of the three series, "Smithsonian Contributions to Knowledge," in quarto (of which 23 volumes have been printed), the "Smithsonian Miscellaneous Collections," in octavo (now numbering 27 volumes), and the annual "Reports" of the Institution, extending from 1847 to 1882, inclusive.

The "Smithsonian Contributions" and "Miscellaneous Collections" include all publications made primarily under the auspices of the National Museum, as well as the annual "Proceedings" of the three principal societies of Washington, namely, the Philosophical, the Anthropological, and the Biological Societies. The societies in question pay for the type-setting of their volumes, and print an edition for distribution tion to their own members. The Smithsonian Institution, however, charges itself with supplying these books to public libraries and learned societies at home and abroad, and has the pages stereotyped, and the usual edition of 1,500 copies printed at its own expense.

The first publication made by the Smithsonian Institution, nearly forty years ago, consisted of a memoir by Messrs. Squier and Davis upon the ancient monuments of the Mississippi Valley, a work which marks the initial point of the great advancement made in the department of archæology in later years. The subject continues to be one of much interest to the Institution, special attention having been

given to securing as complete a series of archæological specimens as possible for preservation in the National Museum. For several years past Dr. Rau, the curator of the Department of Archæology, has been working in the direction of further publications on this subject; a valuable paper prepared by him having been printed in 1876, for use in connection with the Centennial Exhibition, and which has since then been the principal manual of information on the subject.

Dr. Rau is also superintending the preparation of drawings, by Mr. C. F. Trill and others, of all the typical forms of stone implements and objects not already figured in the Smithsonian publications. This is a work of great magnitude, but it is hoped to commence the publication of a new and systematic memoir at an early date.

Smithsonian Contributions to Knowledge.—Of the quarto series of publications no volume has been actually published during the year. A memoir by Dr. Charles Rau on "Prehistoric Fishing in Europe and North America," as illustrated by the archæological specimens collected by the Institution, comprising about 350 quarto pages, has, however, been put entirely into type, and, on the completion of an index, will be issued.

The title of this work sufficiently explains its purport. The descriptive portion is altogether based on existing antiquities bearing either unmistakably or presumably on fishing in prehistoric times, and no conclusions whatever have been drawn exceeding the somewhat narrow compass limited, as it were, by those tangible tokens. If the work had been exclusively designed for persons well acquainted with the results of prehistoric investigation in Europe, the author might have considerably abbreviated its first part by excluding much introductive and descriptive matter. But as it also may be read by non-archæologists, he has deemed it proper to dwell on the differences between the palæolithic and neolithic ages, to give accounts of the tool and bone bearing drift-beds, the cave-habitations, artificial shell-deposits, lake-dwellings, and, finally, to present a brief characterization of the bronze age. Most of these introductions are followed by a section, or sections, devoted to notices of fish-remains, descriptions of fishing implements and utensils, and suggestions in regard to the probable methods of fishing during the period under consideration. The curious tracings of fishes and aquatic mammals, characteristic of the reindeer-period, are treated in a separate division.

In the first section of the second part, relating to prehistoric fishing in North America, the available relics bearing on fishing, such as straight bait-holders, fish-hooks, harpoon and arrow heads, nets, sinkers, and fish-cutters, are described and figured, most of the objects being specimens in the United States National Museum. Boats and their appurtenances are next considered, and then follows an account of some prehistoric structures connected with fishing. In the subsequent di-

vision plastic and graphic representations of fishes, aquatic animals, &c., are treated, and finally a somewhat extended account of artificial shell-deposits in various parts of North America is given.

Pages 261 to 318 contain extracts from various writings of the 16th, 17th, 18th, and 19th centuries, in which reference is made to aboriginal fishing in North America.

In an appendix of 17 pages notices of fishing implements and fish-representations discovered south of Mexico are given.

The volume embraces, without the index, XVIII, 335 pages, and is illustrated with a frontispiece and 405 figures in the text. Nearly all the illustrations have been specially drawn for the work.

Smithsonian Miscellaneous Collections.—In continuation of a former series, vol. VI of the "Bulletin of the Philosophical Society of Washington" has been published as No. 543. It comprises the proceedings of the society for the year 1883 (from the meeting of January 3 to that of December 19), and forms an octavo volume of LII pp. introductory + 168 pp., including an index; in all, 220 pp.

No. 544 of Smithsonian publications in like manner comprises the "Transactions of the Anthropological Society of Washington." Vol. II, from February 1, 1882, to May 15, 1883; forming an octavo volume of XIII + 211 pp.; in all, 224 pp.

No. 561 is a reprint of an article by General J. H. Simpson, U. S. A., on "Coronado's March in Search of the 'Seven Cities of Cibola,' and Discussion of their probable Location," originally published in the Smithsonian Report for 1869. This interesting memoir had never been separately published, and the frequent inquiries for it seemed to justify its reproduction. It forms an octavo pamphlet of 34 pp., illustrated by a sketch map of Mexico (2 pp., 8vo), indicating the route pursued by Coronado and his army, which extended as far north as the fortieth parallel of latitude, near the present boundary separating the State of Kansas from that of Nebraska.

No. 571 is "Check List of Publications of the Smithsonian Institution from December, 1881, to March, 1884." 8vo, 8 pp.

No. 573 is "Price List of Publications of the Smithsonian Institution" to March, 1884. 8vo, 7 pp.

No. 574 is "An Account of the Progress in Astronomy in the year 1883." By Prof. Edward S. Holden. An octavo pamphlet of 78 pp. This forms part of the annual scientific record which has for some years past been prepared at the expense of the Institution for the Smithsonian report.

No. 575 is "An Account of the Progress in Geology in the year 1883." By Dr. T. Sterry Hunt. 8vo pamphlet of 22 pp.

No. 576 is "An Account of the Progress in Geography in the year 1883." By Commander F. M. Green, U. S. N. 8vo pamphlet of 17 pp.

No. 578 is "An Account of the Progress in Physics in the year 1883." By Prof. George F. Barker. 8vo pamphlet of 52 pp.

No. 579 is "An Account of the Progress in Chemistry in the year 1883." By Prof. H. Carrington Bolton. 8vo pamphlet of 31 pp.

No. 580 is "An Account of the Progress in Mineralogy in the year 1883." By Prof. Edward S. Dana. 8vo pamphlet of 19 pp.

No. 581 is "An Account of the Progress in Botany in the year 1883." By Prof. William G. Farlow. 8vo pamphlet of 18 pp.

There has also been reprinted an edition of No. 34 (originally published in March, 1859): "Directions for Collecting, Preserving, and Transporting Specimens of Natural History." Third edition. 8vo pamphlet of 40 pp.

Forest Trees.—Among the earliest objects receiving the attention of the Smithsonian Institution was the preparation of a work upon the "Forestry of North America," under the direction of Dr. Gray, and for which quite a number of plates were prepared more than thirty years ago.

In part the cost of the publication and in part the pressure of other duties upon Professor Gray have prevented the completion of this memoir; and a proposition having been made by Prof. C. S. Sargent, of Brookline, Mass., to take up and complete the work, the same was accepted, and Mr. Faxon was authorized to make the necessary drawings of the trees from living or fresh specimens. The magnitude, however, of this undertaking proved to be a little more than the Institution could compass, and an arrangement has recently been made with Professor Sargent to refund the cost of these drawings and to receive them, so that he may use them in the publication which he has arranged to make with a private publisher.

Among the treatises in preparation for publication by the Institution may first be mentioned the beginning of a complete work on the "Botany of North America," by Prof. Asa Gray.

Part II is in press. It comprises the Gamopetalous orders from *Caprifoliaceæ* to *Compositæ*, inclusive. An enumeration by the author indicates that of the *Caprifoliaceæ* there are 8 genera and 47 species; of *Rubiaceæ*, 26 genera and 86 species; of *Valerianaceæ*, 2 genera and 22 species; of *Dipsacaceæ*, 1 genus and 2 species (naturalized); of *Compositæ*, 237 genera and 1,610 species. It will form an octavo volume of nearly 500 pages.

Bulletins of the National Museum.—As explained in the last annual report, a supplementary edition of the Bulletins of the United States National Museum, from the stereotype plates issued under the direction of the honorable Secretary of the Interior, is printed at the expense of the Institution, and is included in the Smithsonian Miscellaneous Collections. Seven scientific monographs on the geology and on the flora and fauna of Bermuda, extracted from Bulletin No. 25 of the Museum series, have been thus reproduced during the year.

"The Geology of Bermuda, by William North Rice, Ph. D." (No. 563

of the Smithsonian publications), forms an octavo pamphlet of 32 pages.

"The Botany of Bermuda, by General Sir John Henry Lefroy, F. R. S." (No. 564), forms an octavo pamphlet of 109 pages, illustrated with 5 wood-cut plates.

"The Mammals of Bermuda, by J. Matthew Jones, F. R. S. C." (No. 565), forms an octavo pamphlet of 19 pages.

"The Birds of Bermuda, by Capt. Saville G. Reid, F. Z. S." (No. 566), forms an octavo pamphlet of 117 pages.

"On a Bird new to the Bermudas, with Notes upon several species of rare or accidental occurrence in these islands, by Clinton Hart Merriam, M. D." (No. 567), forms an octavo pamphlet of 4 pages.

"The Reptiles of Bermuda, by Samuel Garman" (No. 568), forms a pamphlet of 19 pages, illustrated with 6 wood-cut plates, containing 91 figures.

Annelida from Bermuda, by H. E. Webster (No. 569), forms an octavo of 26 pages.

Proceedings of the National Museum.—This series (as heretofore explained) comprises carefully prepared memoirs on new and interesting specimens and articles collected for the National Museum, and printed as soon as material for a "signature" of 16 pages is made up. This series, like that of the "Bulletins," is primarily published and stereotyped under the authority and direction of the honorable Secretary of the Interior. These articles or contributions comprise, first, papers prepared by the scientific corps of the National Museum; secondly, papers by other naturalists based on the Museum collections; and, lastly, of memoranda and interesting information gathered from the correspondence of the Smithsonian Institution.

Volume VI of the "Proceedings of the United States National Museum" for 1883 (Smithsonian No. 548) was completed and published during the past year. The volume contains papers by Tarleton H. Bean, L. Belding, Katherine J. Bush, W. H. Dall, William J. Fisher, James M. Flint, Charles H. Gilbert, Theodore Gill, G. Brown Goode, G. H. Heap, William T. Hornaday, Frederick Humbert, J. G. Hunt, David S. Jordan, Pierre Louis Jouy, George P. Merrill, E. W. Nelson, A. P. Niblack, Charles C. Nutting, Richard Rathbun, Charles Rau, Robert Ridgway, John A. Ryder, Rosa Smith, Sidney I. Smith, Robert E. C. Stearns, W. A. Stearns, Leonhard Stejneger, Joseph Swain, Frederick W. True, S. T. Walker, Charles A. White, Merritt Willis, and H. C. Yarrow. It forms an octavo volume of VII + 558 pages, illustrated with 6 wood-cuts in the letter-press, and 14 wood-cut plates.

Smithsonian Annual Report.—The Annual Report of the Regents of the Institution to Congress for 1882, submitted January 19, 1883, was not actually published and ready for distribution till the past year, 1884. The volume contains the Journal of Proceedings of the Board of Regents, the reports of the Executive Committee of the Board, and of the Secretary

of the Institution, together with the "General Appendix," which comprises the usual scientific record for the year, namely, an account of the progress in Astronomy, by E. S. Holden; in Geology, by T. Sterry Hunt; in Geography, by F. M. Green; in Meteorology, by Cleveland Abbe; in Physics, by G. F. Barker; in Chemistry, by H. Carrington Bolton; in Mineralogy, by Edward S. Dana; in Botany, by W. G. Farlow; in Zoology, by Theodore Gill; and in Anthropology, by O. T. Mason; concluding with a selection of miscellaneous papers on American aboriginal remains, contributed by correspondents of the Institution. The Report forms an octavo volume of xx + 855 pages, the archæological papers being illustrated by 46 wood-cuts and topographic sketches of mound localities.

The Annual Report for 1883, I regret to say, has not yet been published.

The reports on the progress during the year of the various branches of science have been continued, and meet with very hearty favor, especially on the part of teachers, who find in them material for presentation to their classes, not otherwise accessible at the time, excepting to those who have command of a vast number of scientific journals. Among these reports, and one of special interest, is that upon the progress of meteorology, prepared by Professor Abbe. To make this specially serviceable, a detailed index was necessary; but it was not possible to have this completed before it became necessary to put the report to press. The index was, however, prepared, and has been appended to the extra copies.

INTERNATIONAL EXCHANGES.

The operations of this important branch of the Institution have been carried on with vigor during the past year. Great inconvenience was experienced during the winter of 1883–'84 owing to the limited quarters available for exchange work during the reconstruction of the eastern portion of the Smithsonian building. On the completion of the first floor of this edifice five rooms were assigned to this department and two in the basement; several new assistants were appointed, and I am happy to state that ample facilities are now provided for the prompt and efficient discharge of business. The work, however, is constantly growing and demands unceasing attention.

Mr. George H. Boehmer, in charge of the international exchanges, has been in Europe for a large part of the year, engaged in taking the necessary measures to improve and reorganize the relationships of the Smithsonian Institution to the European service of international exchanges. A full account of his operations will be given in the next annual report.

Congressional Aid.—The appropriation by Congress for the exchange system, under direction of the Institution, was increased for the year 1884–'85 from $7,500 to $10,000. Without this aid it would be impossible for the Institution to continue its gratuitous service to the libraries

and societies in this country which have so long enjoyed the benefits of the system.

Liberality of Transportation Companies.—Thanks also to the liberality of the principal steamship companies, the packages of the Institution are still carried free of freight, a concession amounting to several thousand dollars a year in value. Acknowledgments are due to the following companies and firms for this voluntary service:

Am. Colonization Society, Washington, D. C.; Anchor Steamship Co. (Henderson & Bro., agents), N. Y.; Atlas Steamship Co. (Pim, Forwood & Co., ag'ts), N. Y.; H. B. Bailey & Co., N. Y.; E. R. Biddle, Philadelphia; Thomas Bixby & Co., Boston, Mass.; Thomas Bland, N. Y.; B. R. Borland, N. Y.; R. W. Cameron & Co., N. Y.; Compagnie Générale Transatlantique (L. de Bébian, ag't), N. Y.; Cunard Royal Mail Steamship Line (Vernon H. Brown & Co., ag'ts), N. Y.; Dallett, Boulton & Bliss, N. Y.; Thomas Dennison, N. Y.; Hamburg-American Packet Co., (Kunhardt & Co., ag'ts), N. Y.; Inman Steamship Co., N. Y.; Merchants' Line of Steamers, N. Y; Monarch Line (Patton, Vickers & Co., ag'ts), N. Y.; Muñoz y Espriella, N. Y.; Murray, Ferris & Co., N. Y.; Netherlands-American-Steam Navigation Co., (H. Cazaux, ag't), N. Y.; New York and Brazil Steamship Co., N. Y.; New York and Mexico Steamship Co., N. Y; North German Lloyd (Oelrichs & Co.), N. Y., (Schumacher & Co., ag'ts,) Baltimore; Pacific Mail Steamship Co., N. Y.; Panama R. R. Co., N. Y.; Red Star Line (Peter Wright & Sons, ag'ts), Philada. and N. Y.; Spinney, Joseph, S., N. Y.; Steamship Lines for Brazil, Texas, Florida, and Nassau, N. P. (C. W. Mallory & Co., agents), N. Y.; White Cross Line of Antwerp (Funch, Edye & Co., agents), N. Y.; Wilson & Asmus, N. Y.

The Pennsylvania Railroad Company and the Baltimore and Ohio Company have continued their concessions of reduced fares, and the freight steamer lines between Washington and New York have also made liberal concessions, which have been of very great value.

Acknowledgments are also due to the foreign ministers and consuls of the various Governments for their assistance in taking charge of the packages intended for the countries which they respectively represent and transmitting them with care to their destination.

The following tables will give the statistics for 1884:

RECEIPTS.

Purpose for which received.	Packages.	Weight.
1. For foreign distribution	18,866	78,732
2. For domestic distribution	7,967	42,255
3. For Government exchanges	38,337	32,827
	65,170	lbs. 153,814

Representing an increase over 1883 of about 1,500 packages.

TRANSMISSIONS.

1. Foreign exchanges: 537 boxes, representing a bulk of 3,531 cubic feet, with a weight of 131,350 pounds, being an increase of 118 boxes over the year 1883.
2. Domestic exchanges: 10,236 packages, of which 8,094 were addressed to institutions, and 2,142 to individuals.
3. Government exchanges: 114 boxes, representing a bulk of 750 cubic feet, with a weight of 27,885 pounds, against 76 boxes in 1883; or an increase of 38 boxes, as compared with that year.

The increase over the year 1883 is most noticeable in the foreign and Government exchanges, being 156 boxes, with a bulk of 993 cubic feet and a weight of 36,970 pounds.

In the domestic exchanges there is an apparent decrease in the number of parcels, but this is owing to the fact that packages arriving by mail for the Smithsonian library were formerly recorded by the exchange office, while during a great portion of the year 1884 this practice had been discontinued.

Government Document Exchange.—The exchange of official publications of the United States Government for those of most other foreign nations has been continued, as in previous years, under the auspices of the Smithsonian Institution, in accordance with the law of Congress, and a large number of valuable publications have been sent to agencies designated by their respective countries.

During the year the Government of Great Britain has agreed to make a complete exchange of all official documents, commencing with January 1, 1882, and preliminary arrangements have been made to the same effect with the Government of Austria.

There are now thirty-eight foreign Governments regularly receiving the publications of the United States.

For some time there has been considerable difficulty in establishing the regular international exchange connection with the British Provinces and the United States. A satisfactory arrangement, however, has been made with the Geological Survey at Ottawa to receive and distribute all parcels belonging to Canada proper, and by the kind aid of Mr. Matthews, of St. John, N. B., Mr. Kane, of the custom-house at St. John, has agreed to receive parcels for Nova Scotia, New Brunswick, and Prince Edward Island, and to assess pro rata the freight expenses upon the recipients. There only remains to make some satisfactory arrangement with Newfoundland to complete the British provincial service, which it is thought can be accomplished before long.

Public Utility of the Smithsonian Exchanges.—The practical benefits of the Smithsonian exchange system are extended to the remotest quarters of the earth; and have been frequently acknowledged by eminent scientific workers abroad. It has even been suggested that in the interest of science, similar agencies in Great Britain and elsewhere, are a great desideratum, notwithstanding the increasing activity among

European Governments in promoting international exchanges of official publications. In a communication published in *Nature*, October 30, 1884 (vol. xxx, p. 634), Prof. V. Ball, of the chair of Geology and Mineralogy in the University of Dublin, in warmly commending "the extraordinary liberality of the American Government" in its free distribution of the Geological Survey Reports, and other valuable works, remarks as follows:

"We owe much of this liberality, no doubt, to the forethought and generosity of our own countryman, Smithson, the principal function of the Institution founded by him, being to arrange for the exchange and dispatch of books and specimens.*

"There are perhaps few directions in which the cause of science would be more directly benefited just now than by the establishment of an institution in England which would undertake the management of the exchanges of the scientific societies of the United Kingdom. I am aware that there are paid agencies for the purpose, but what is wanted is a free agency which would undertake the duty for the large societies and relieve those that are struggling from charges which now press heavily on their resources.

"The great desideratum, however, is a man like Smithson, who, possessing wealth, would be willing to give or bequeath it for the purpose of founding such an institution. Here is an opportunity for any person of capital—desirous of doing good and preserving his name to all posterity by one and the same act.

"To return, however, to the main object of this letter, cannot anything be done to increase the 'free list' of Government publications? Surely there must be stored away vast quantities of survey and other serial publications, which if they were handed over to the Smithsonian Institution, would, I feel certain, be gratefully accepted and judiciously distributed among the libraries of America."

Difficulties of prompt Delivery.—It is perhaps proper to call attention to the fact that the Institution does not undertake to act as an express agency, guaranteeing to deliver packages in the most expeditious manner and securing prompt returns. The number of correspondents is so large, the places to be reached so numerous and some of them so difficult of access, that delays of weeks and even of months are frequently necessary. The Institution desires to secure the speedy delivery of everything intrusted to it, not only for the sake of the senders and the credit of the exchange agency, but because the constant accession of packages is so great that it is not possible to allow them to accumulate.

It is very desirable that officers of societies or individuals who avail themselves of the Smithsonian service should not inform the parties for whom packages are intended in foreign countries that they have been sent until the date of actual shipment is ascertained. This is a cause of frequent complaint and misunderstanding, and might be entirely prevented by due consideration of the case.

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* This is really but one of the functions of the Institution, co-ordinated with that of promoting original research.

LIBRARY.

The following is a statement of the books, maps, and charts received by the Smithsonian Institution during the year 1884 and transferred to the Library of Congress or to that of the National Museum:

Volumes:		
Octavo or smaller	1,222	
Quarto or larger	345	
		1,567
Parts of volumes:		
Octavo or smaller	3,983	
Quarto or larger	4,843	
		8,826
Pamphlets:		
Octavo or smaller	1,979	
Quarto or larger	344	
		2,323
Maps and charts		143
Total		12,859

RELATIONS OF THE SMITHSONIAN INSTITUTION TO OTHER BODIES.

I. *To the Government—Congress.*—Ever since the completion of the new wings of the Capitol, the proper ventilation of the House of Representatives has been a subject of anxiety to its members, and several commissions of civilians have been appointed to consider the question. Of these Professor Henry was chairman, and at the time of his death, in 1878, he had completed a renewed inquiry on the subject, and prepared a report upon the same. In this office I succeeded Professor Henry, and again, in February, 1884, was asked to form one of an advisory committee (the other members consisting of Colonel Casey, of the United States Engineers, Mr. Edward Clark, Architect of the Capitol, and Dr. J. S. Billings, of the Army Medical Museum) to assist the standing committee of the House of Representatives in its deliberations. The question having arisen as to the purity of the air in different parts of the hall and its approaches, a chemical analysis of the same was made by Dr. J. H. Kidder, U. S. N., with the assistance of Mr. R. L. Packard of the Bureau of Education, and some interesting and important statements and generalizations were furnished. Their work was completed on the 2d of April, and a report furnished in the same month and published as a part of Report No. 1970, Forty-eighth Congress, first session. The conclusions of the report are that—

1. The chemical examinations and tests indicate no impurity in the air supplied to the House, nor unwholesome change during its passage through the air-duct or the hall.

2. The air in the corridors and stairways is much less pure than that of the hall. * * *

5. The "relative humidity" as observed is about 20 per cent. below the accepted standard, and probably falls much lower in cold weather.

6. The ventilation of the southeast gallery appears to be insufficient.

This examination, which included the estimation of 65 samples of air, and numerous hygrometric and anemometric observations, agrees substantially as to results with those undertaken by Professor Henry and Dr. Charles M. Wetherill in 1865–'66 (House Ex. Doc. No. 100, Thirty-ninth Congress), and by Dr. Charles Smart, U. S. A., in 1880 (MS. report to the Advisory Board).

Navy Department.—Reference has been made in previous reports to the arrangement by which, at the request of the Navy Department, the institution received for three successive years six Ensigns, and assigned them to duty in various sections of the National Museum for the purpose of enabling them to become acquainted with certain branches of science, such as chemistry, mineralogy, geology, ethnology, general natural history, &c., in order that in their subsequent cruises they might be more useful. Three details of the kind have been made, none, however, in 1884, the Department having found it inexpedient to continue the arrangement. Most of the gentlemen already detailed have also been reclaimed and assigned to duty. Two of these Ensigns, Messrs. Miner and Garrett, are now on the Fish Commission steamer "Albatross." Ensign Hayden was detached in October and ordered to duty, first at the Cambridge Observatory and subsequently to the United States Geological Survey. At present there are but two of these gentlemen left, and they are daily expecting their orders.

The experiment in connection with these junior officers of the Navy has been very satisfactory as far as it has gone, and there can be no doubt that the increased range of information thus acquired by the eighteen gentlemen so detailed will be utilized to a greater or less extent in the future.

As in previous years, the Navy Department has had charge of the administration of the department of *materia medica* in the National Museum, which renders unnecessary the establishment of a similar bureau in the Navy Department itself. The first officer detailed by the Medical Department for this purpose was Dr. J. M. Flint, under whose efficient administration the collection was thoroughly organized and placed in working order. On Dr. Flint's transfer to the steamer "Albatross," in 1884, Dr. H. J. Beyer, of the Navy, was ordered to his place, and gives general satisfaction.

Lieutenant Bowles, attached to the U. S. S. "Adams," stationed at Sitka for some time past, was enabled to make some interesting collections for the National Museum, and when this vessel was under orders to return to San Francisco, Lieutenant Bowles made application for an exchange of service with an officer of the "Pinta," so as to remain on that vessel and continue his work. This request was granted by the Navy Department with its usual courtesy.

Naval Observatory.—The Institution is indebted to the courtesy of the Superintendent of the United States Naval Observatory for including its building and that of the National Museum in the series of public establishments which receive telegraphic time at noon on each successive day, and a clock, fitted up under the direction of the Observatory, with an arrangement by which the observatory itself corrects any aberration in time, has been supplied, and although the money expense has been borne by the Institution, yet no charge has been made for the time service.

War Department.—The Signal Service has continued during the year that co-operation which has heretofore been found very serviceable, especially through its agencies in Labrador and Alaska. More particular reference will be made to this subject in the chapter on Explorations, but it may be well here to particularize the work of Mr. Lucien M. Turner at Fort Chimo, Ungava Bay, Northern Labrador; of Messrs. Murdoch and Smith, at Point Barrow; Dr. Stejneger, at the Commander Islands, &c.

By the kindness of the Signal Office, Mr. John J. McLean, who has rendered very much aid to the institution in its work while resident in Alaska, was again ordered to that country by the chief signal officer. The lamented death, by drowning, of Mr. C. L. McKay, in the vicinity of Nushagak, Bristol Bay, was mentioned in the preceding report. The vacancy thus effected was filled by the Signal Office by the appointment of Mr. J. W. Johnson, of East Rockport, Ohio. This gentleman is a naturalist of considerable experience, and will continue Mr. McKay's work of securing such specimens of natural history as he can find time to prepare in the intervals of his regular official work for the Signal Service.

By the courtesy of Colonel Rockwell, Superintendent of Public Buildings and Grounds, the Institution was enabled to make connection with the underground telephone laid by his authority through the public grounds by the Waring Company. A special advantage in this was the opportunity of making a more satisfactory connection between the National Museum building and the United States carp ponds, a service that previously had been much interrupted. Connection was also made through the same trench with the Fire-Alarm Telegraph Company, and the necessary permission to open North B street was promptly granted by the District Commissioners.

Treasury Department.—The Director of the Mint, at the request of the Institution, has furnished for display in the National Museum two sets, in bronze, of all the medals struck at the United States mints. These are of great historical value, and when properly installed will doubtless be very attractive to the public.

Light-House Board.—The usual courtesies of the Light-House Board have been extended in the way of co-operation in obtaining data by which to determine the temperatures of the waters of the Atlantic

Ocean, with a view of investigations into the causes of movements of fish and other marine animals.

On the application of the Institution in behalf of the American Ornithologists' Union the Board also promptly gave instructions to light-house keepers to keep the record of migrations of birds as shown principally by their being picked up after striking against the light-houses on dark nights.

The instructions of the Life-Saving Service to its agents to co-operate with the Institution in its investigations have also borne good fruit in the way of collecting information of the occurrence of rare and interesting forms of marine animals.

In order to increase in every possible way the material in the department of *materia medica* in the National Museum, above referred to, under the Navy Department, application was made to the Treasury Department for instructions to the collectors of customs in the seaboard cities to transmit samples of drugs submitted by specialists for investigation, so as to serve as illustrations of both the crude importations and the adulterations attempted from time to time by importers. A favorable response was made, and quite a number of collections have already been received.

The usual courtesies of the Revenue Marine to the work of the Smithsonian have been continued during the year, the chief of the bureau having instructed its captains in Alaska to further Mr. Swan's proposed exploration for the Institution by receiving him and his collections on board whenever such action will not interfere with the regular service of the vessels. Captain Healy, of the "Corwin," has also, by the authority of the bureau, continued to make important contributions of collections.

The chief of the Bureau of Revenue Marine also kindly instructed the commander of the revenue steamer "Key West" to assist Mr. Hemphill in carrying on his explorations of the Florida keys in behalf of the National Museum.

Interior Department.—It has always been the policy of the Smithsonian Institution to make amicable arrangements with the various Departments of the Government by which to avoid duplication of effort in material. This has been shown in many ways, as in the arrangement with the Commissioner of Agriculture to transfer all specimens of plants and insects to that establishment and all human crania to the Army Medical Museum, receiving from them in return whatever might belong to the department of general natural history and ethnology.

A second instance of this spirit was shown in the transfer to the United States Signal Service of the results of the meteorological correspondence and labors which had been so effective in the hands of the Smithsonian Institution for nearly twenty-five years.

Major Powell, of the United States Geological Survey, has organized a special department of maps and charts, with a view of utilizing the

information they contain in his work, or of having standards of comparison for his own draughtsmen and engravers. The Smithsonian Institution has been accumulating material of this kind for nearly forty years, embracing many thousands of sheets, and the offer of this to Major Powell was promptly accepted, with the assurance that it would be properly classed and arranged, and be at all times at the command of the Institution.

The co-operation of the Secretary of the Interior has been especially manifested in connection with the publications of the National Museum, and of the printing required for labels, blanks, &c. All the expenditures of appropriations made by Congress for preservation of the collections of the Government, the construction of cases and fixtures, the payment of salaries of Museum employés, &c., are made through the disbursing officer of the Interior Department, Mr. G. W. Evans, and the annual estimates for the service of the Museum, for postage, printing, and blanks, are made through its Secretary.

Railroad and Steamboat Lines and other Corporations.—As in previous years, the various railroad lines of the country and the foreign steamship companies have rendered aid either in the entire reduction of charges or through a very large remission of charges. The number has increased of steamship companies furnishing free freights to the parcels of the Smithsonian Institution, especially those connected with the International Exchanges; a list of these is subjoined. The services rendered by these companies is of the utmost possible benefit, not only in the very great reduction of transportation to the Institution, but also in the greater care exercised in handling the packages. Among the additional companies to which the Institution is under obligation may be specially mentioned the Atlas Steamship Company, the vessels of which, under the direction of Messrs. Pim, Forwood & Co., make connection with nearly all ports of the West Indies and Central America.

The Institution is indebted to the Merchants and Miners' Transportation Company for greatly reduced rates of freight between Washington and Boston. This is a privilege of great importance, as sometimes there is a large amount of freight to be carried by this route.

Mr. C. G. Prindle, a well-known botanical collector, undertook an exploration of the region adjacent to the boundary line between the United States and Mexico west of El Paso, and at the request of the Smithsonian Institution the Atlantic and Pacific Railroad Company gave passes to himself and assistant, which greatly facilitated their work. An exceptionally wet season brought about an unusual development of vegetation, and many points of interest were visited by Mr. Prindle in the course of his labors with rich results.

To General Manager Robinson, of the Atchison, Topeka and Santa Fé Railroad, the Institution is indebted for a free pass for the year 1885, to be used by one of its employés in an exploration of the natural history along the line of that road.

The Alaska Commercial Company has continued its liberal and important aid to all the operations of the Institution on the Pacific coast.

The co-operation of the Hudson's Bay Company in the work of the Smithsonian Institution, which commenced as long ago as 1858, has been continued through successive years; the latest instance being the courtesy by which Mr. Lucien M. Turner was enabled to spend two years at Ungava Bay, in Northern Labrador, in the service of the United States Signal Office and of the Smithsonian Institution. The company has also granted the necessary authority, and has given instructions to its agents in this country in connection with the proposed exploration of the region about the mouth of the Mackenzie River.

Co-operation with the American Association.—At the meeting of the American Association for the Advancement of Science, held at Montreal in 1882, a committee was appointed, consisting of Professors H. Carrington Bolton, Ira Remsen, F. W. Clarke, Albert R. Leeds, and Alexis A. Julien, "to devise and inaugurate a plan for the proper indexing of the literature of the chemical elements." To forward this useful enterprise the Smithsonian Institution undertook to distribute for the committee any circulars or other documents issued by its authority. At the next meeting of the Association, held at Minneapolis in 1883, the committee on indexing reported progress, and acknowledged the friendly offices of the Institution as "an offer of great importance, and for which this committee expresses sincere thanks."

In further aid of a work so valuable to chemical research and to the advancement of science this Institution has also announced its readiness to undertake the publication of the various bibliographical indexes compiled under the auspices of the committee; not, however, in excess of fifty pages per annum. At the meeting of the Association held at Philadelphia last September (1884) the committee on indexing reported a number of special indexes as completed, and stated:

"Two hundred and fifty copies of our report for 1883 have been sent to chemists throughout the United States, the Smithsonian Institution having kindly attended to the distribution by mail without expense to the committee. This led to correspondence with several chemists, who regarded the scheme of co-operative indexing favorably, and resulted in several offers of assistance.

"We are pleased to announce that in consequence of our representations the Smithsonian Institution has consented to publish indexes to chemical literature which shall be indorsed by this committee. The Smithsonian Institution places a limit to the number of pages which will be printed per annum, but the limit is a generous one. By thus securing the assistance of the Smithsonian Institution chemists are assured of a reliable and authoritative channel of publication, together with a wide circulation, and the plan of co-operative indexing will undoubtedly receive a great stimulus."

The committee's report for 1884, extracted from the proceedings of the American Association for the year, was published as a three-page circular in October, and the same has been distributed by this Institution

to chemists and others interested in the subject. A copy of this circular is appended to this report.

Electrical Exhibition at Philadelphia.—An "International Electrical Exhibition," under the direction of the Franklin Institute of the State of Pennsylvania, was held at Philadelphia from September 2 to October 11, 1884. Although the activities of the Institution have not for many years past been directed to the extension of our knowledge in the field of electrical science, nor any recent memoirs on the subject published under its auspices, yet, as expressive of the interest felt in the proposed movement, an exhibit was prepared and forwarded to the directors before the opening of the exhibition. This exhibit comprised two quarto volumes of original memoirs relating to electricity and magnetism; collected from the Smithsonian Contributions to Knowledge (averaging about 500 pages each), with specially-prepared title-pages, and neatly bound; and also three octavo volumes on the same subject, collected from the miscellaneous papers published at various times in the annual Reports of the Institution, in like manner supplied with appropriate title-pages, and neatly bound in a uniform style. These five volumes were presented to the Franklin Institute as a permanent contribution to its memorial electrical library. A framed portrait of Professor Henry, of life size, in crayon, by Mr. H. Ulke, was also forwarded for exhibition, with a framed legend attached, briefly stating the more important contributions of the late Secretary of the Smithsonian Institution to the scientific and practical applications of electricity.

In addition to these, the original telegraphic instrument constructed for Professor Morse by Mr. Alfred Vail, and operated by them in the first experimental communication by electro-magnetism between Baltimore and Washington (May 24, 1844)—on deposit in the National Museum—was loaned to the Exhibition, by permission of Mr. Stephen Vail, the owner and depositor of the instrument, and placed in its hall of historical relics and memorials.

For the purpose of having the interest of the Smithsonian Institution represented, Mr. William B. Taylor was commissioned to attend the Electrical Exhibition to see after the exhibits of the Institution, and to make such general examination of the extent, character, and details of display as might prove instructive or useful. Mr. Taylor remained at Philadelphia on this service one week, the cost to the Institution being only his traveling expenses.

State and International Exhibitions.—The time and attention of the officers of the Smithsonian Institution have been occupied for a number of years past in the preparation of displays for exhibitions, national and State. Notably among them may be mentioned the International Exhibition at Philadelphia in 1876, the Berlin Fisheries Exhibition in 1880, the Louisvillle Exhibition in 1883, the London Fisheries Exhibition in the same year, and, in 1884, the exhibitions at Louisville and Cincin-

nati, and the International Cotton Exposition at New Orleans, opening in December, 1884.

Many applications are made from time to time to the Institution for material for display, but in every instance they have been declined, unless an act of Congress has been passed authorizing the same, and making the necessary appropriation. It is considered that the Institution has no right to allow any of its collections to leave the walls of the Museum without such authority, and as the appropriations are each made for a specific purpose, all expenditures of the same are strictly applied as designated.

Great confusion is generally caused in the regular work of the National Museum, as the time of the curators and assistants is occupied in spasmodic efforts, apart from the regular continuous work necessary to properly install and label the permanent collections. This condition is cheerfully met, however, as the appropriations are generally such as permit, and, indeed, require, the acquisition of new material which may not be attainable excepting by purchase or expenditure of some kind. Thus, with the help of the appropriations for the Berlin and London displays, the Museum has acquired what may safely be considered the most complete exhibition of fishery apparatus, methods, and products ever combined under one roof, and constituting an object of great attraction to visitors. The experience of the present year is also in the same direction; all funds available being expended specially in procuring material illustrative of archæology and ethnology, and in bringing together very extensive representations of the general industries of the United States connected with textile materials, metallurgy, &c. The increase in the collections of the Museum by this means and others is so rapid as to involve the necessity for the speedy erection of a new building for their proper accommodation.

In accordance with an act of Congress making provision for the participation by the United States in the International Cotton Exhibition at New Orleans, Mr. G. Brown Goode was nominated as the representative of the Fish Commission on that occasion and was duly commissioned to that effect in May last. In conjunction with the representatives from other departments, Mr. Goode has been diligently occupied in his labors, which were brought to a satisfactory conclusion by the transmission of several car-loads of objects to New Orleans in December last.

Prior to the transmission of collections to New Orleans, extended displays were made at the exhibitions in Cincinnati and Louisville, some of which have been returned to the Institution and others forwarded direct to New Orleans.

NECROLOGY.

Dr. ARNOLD HENRY GUYOT, one of the earliest contributors to the interests and the publications of the Smithsonian Institution, is one whose death early in the past year we have to lament. Born at Boudevilliers, near Neuchatel, in Switzerland, September 28, 1807, he entered the

second class of the college of Neuchâtel in 1821, going thence to Carlsruhe (where, in 1825, he formed an intimacy and lasting friendship with Agassiz), afterward to the classical gymnasium of Stuttgardt, returning to Neuchatel in 1827. In 1829 he entered the university at Berlin, from which institution he received the degree of Doctor in Philosophy in 1835. The next four years he spent in Paris, making summer excursions of physiographical observations through France, Belgium, Holland, and Italy, and in 1838 studying glaciers in Switzerland, and investigating the distribution of erratic bowlders. In 1839 he was made professor of history and physical geography at Neuchatel, where his early friend Agassiz had already for some half a dozen years been professor of natural history. Dr. Guyot held this position for ten years, assisting Agassiz in the "Système Glaciaire," published in 1847.

In 1848, Dr. Guyot, at the urgent solicitation of his friend Agassiz, came to this country—the latter having been here already about two years. He was employed for six years by the Massachusetts board of education as lecturer to the normal schools of the State on geography and its methods of teaching. In 1849 a course of his lectures in French on "The Earth and Man" were published in an English translation by Professor Felton.

In 1850 he was invited by the Smithsonian Institution to assist in developing the system of meteorological observations for the North American continent, then recently organized. In addition to valuable suggestions in consultation with other eminent meteorologists, as a needful reference work in the labor of the various reductions from extended observations, Dr. Guyot undertook the collection, computation, and arrangement of a series of graduated tables of constants—physical as well as meteorological—for the use of those engaged in such investigations. This valuable work, comprising 212 printed pages, together with "Directions for Meteorological Observations," comprising 70 printed pages, mainly by the same author, was published in 1852, as the first volume of the "Smithsonian Miscellaneous Collections," and at once became in great demand.

Dr. Guyot at this time made a careful study of the physical geography of the eastern portion of our country from Maine to South Carolina. In 1854 he was elected professor of geology and physical geography in the College of New Jersey at Princeton, a chair which he held till the time of his death, a period of thirty years. A second edition of his standard work, the "Tables," amended and greatly enlarged, was published by the Institution in 1857, and a third edition in 1859, which extended to 638 octavo pages.

He was one of the original members of the National Academy of Sciences at its organization in 1863. In the preparation of Johnson's "New Universal Cyclopædia," a very elaborate and valuable work in four large and closely printed volumes, published in 1875–'78, he was Dr. Barnard's assistant editor-in-chief. Indefatigable in his efforts to

render complete his favorite production, the "Meteorological and Physical Tables," he commenced the preparation of a new edition, with still further additions in 1879, and this fourth edition, embracing about 750 octavo pages, was published by the Institution in the past year. But the distinguished author did not live to see the last pages of the work through the press. He died at his home in Princeton, New Jersey, February 8, 1884, in the 77th year of his age.

HENRY GASS, for many years an employé of the Institution, died at his residence in this city on the 10th of April, 1884, of consumption, at the age of 49 years. He was appointed as a general messenger in February, 1855, and though occupying a comparatively humble position, by his fidelity and attention to his duties he made himself very useful. Of late years he had been intrusted with the mail transmission of Smithsonian publications to individual correspondents and applicants. His health, never very robust, had been declining for a year or two, but he continued at his post till within a few months before his death. Patient and accommodating, he was kindly regarded by all with whom he was brought into intercourse.

CLARENCE BISHOP YOUNG, the accountant of the Institution, died on the 17th of April, 1884. He was born in Halifax, Nova Scotia, on the 3d of February, 1846, but came to the United States with his parents in 1849. He was graduated from Columbian College, Washington City, in 1864, and from Harvard College in 1868. He completed the scientific course in the Lawrence Scientific School. Before entering Harvard he was for two years a clerk in the Fourth Auditor's Office, Treasury Department. After leaving college, and while perfecting himself in mechanical engineering in the city of New York, he was one of the editors of an industrial journal. At the request of Professor Henry he accepted a place in the Smithsonian Institution in 1870 as clerk and book-keeper, which he retained until his death. He always discharged his duties with punctuality, judgment, and accuracy. During his extensive service in the Institution, his modest and courteous demeanor, his readiness to assist others when applied to, and his careful attention to all details submitted to him, won the respect and warm regard of all his associates. He was a fine linguist, and his general scientific culture and critical acumen rendered his services especially valuable in revising papers and printers' proofs for the Smithsonian publications. In 1873 he was commissioned by Professor Henry to attend the Vienna Exposition and visit the various agencies in Europe of the Institution. Ill health, attended with great nervous prostration, compelled him to withdraw from all active occupation for a year before he finally passed away.

MISCELLANEOUS.

Edinburgh Ter-centenary.—The Smithsonian Institution was invited by the University of Edinburgh to send a delegate to be present at the

celebration of its tercentenary, and Hon. J. Russell Lowell, American minister to England, was requested by the Institution to act in that capacity. He did so to its entire satisfaction and gratification, and occupied quite a prominent place on the occasion in question.

Sonorous Sand.—An interesting problem to physicists and geologists has been a sand found in certain localities, which, when placed in motion by sliding, sometimes produces a very sonorous or resonant sound quite peculiar in character and quite difficult of explanation. The subject has received considerable attention from specialists, and Prof. H. C. Bolton, of Trinity College, Hartford, Conn., desirous of making researches on the subject, and especially in studying the microscopical, chemical, and physical peculiarities of the grains, requested the aid of the Institution in obtaining materials for the purpose. Letters were addressed to parties in the Sandwich Islands, the coast of Oregon, Germany, and many other places, and a considerable variety of specimens from various localities has been received in response. These are now in Professor Bolton's hands, who will prepare a report on the subject.

The Mercer Estate.—References have been made in previous reports respecting the will of the Rev. Dr. Mercer, of Newport, in which the Smithsonian Institution and Harvard and Yale Colleges are made trustees to administer certain scholarships.

A question arose as to whether these designations meant the present incumbents of the offices or those who might be in power at the time when the provisions of the will should take effect.

This question having been brought before the courts of Rhode Island, it was decided that reference was made to the officers in the abstract, and not to the individuals, so that whoever may be in charge of the establishments in question when the provisions of the will are carried into effect will be competent to take action. The amount involved at present is about $300,000, and is likely to be doubled before action is required. This action is contingent upon the death of certain legatees, which will not take place, according to the tables of mortality, for about thirty-five years.

Walker Prize.—Dr. William J. Walker a number of years ago bequeathed to the Boston Society of Natural History a prize fund, from the income of which an annual award was to be made to the competitor having written the best essay on specified topics. In addition to these annual awards, an honorary prize of from five hundred or one thousand dollars (at the discretion of the society) is founded, to be awarded every five years, "for such investigation or discovery as may seem to deserve it, provided such investigation or discovery shall have been made known or published in the United States at least one year previous to the time of award." The prize is to be bestowed on recommendation of a special commission appointed by the society for the purpose.

In January of the past year, the Secretary of this Institution was designated as one of such committee (together with Dr. Asa Gray, one of the Regents, and Prof. J. S. Newberry). The prize of $1,000 was awarded on their recommendation to Prof. James Hall, of Albany, by the society, May 7, 1884.

Telegraphic Astronomical Announcements.—In the last annual report (1883) was recorded the final transfer to the Harvard College Observatory of the system of telegraphic announcement of astronomical discoveries inaugurated by this Institution in 1873. The belief was expressed that astronomical interests would be benefitted by placing this useful service in the charge of a working observatory. It is gratifying to learn that the expectation has been justified by the result. In the thirty-eighth Annual Report of the Director of the Astronomical Observatory of Harvard College (Prof. Edward C. Pickering), laid before the Board of Overseers, January 9, 1884, it is remarked:

"The system of announcing astronomical discoveries employed here for some years past has received an important extension during the last year. An association of over fifty observatories has been formed, with its headquarters at Kiel, for the purpose of expediting the announcement of astronomical discoveries. The Smithsonian Institution, which had for many years rendered an important service to astronomy by transmitting astronomical telegrams between Europe and America, courteously signified its readiness to transfer this function to the observatory of Harvard College, upon learning that this observatory was prepared to undertake it. The change was announced by a circular issued by the Smithsonian Institution on January 10, 1883, and since that time the observatory has distributed in this country the astronomical intelligence received from the European association, and has forwarded to Kiel the information of American discoveries."

Special Donations to the Smithsonian Institution.—The relationship of Professor Henry, the first Secretary of the Smithsonian Institution, to the progress of scientific discovery, by which the Morse electric telegraph system was established, must always give an interest to anything illustrating the early history of the invention. Knowing this fact, Mr. Stephen Vail has deposited with the Institution one of the two original Morse telegraphic instruments made for experimental service between Washington and Baltimore, and this has been placed in the National Museum, where it attracts much interest among inventors. By permission of Mr. Vail it was lent for a time to the Electric Exhibition in Philadelphia, but has been duly returned and put in its proper place. Application has been made for it by parties connected with the New Orleans Exposition, and with the permission of the owner, the instrument will be sent to that city.

A life-size statue of Prof. Benjamin Silliman, one of the pioneers of physical science in America, and the founder of the American Journal of Science, was recently modeled by Prof. John F. Weir, cast in bronze (8 feet in height), and placed permanently in Yale College, at New Haven.

Through the kindness of Prof. Benjamin Silliman, son of the eminent savant in question, the model of this statue, in plaster, was presented to the Institution and deposited in the National Museum, where it is proposed to bring together as complete a collection as possible of busts or portraits of the men whose work has definite relationship to the objects of the Institution.

The Institution received, in February, a complete set of standard weights and measures of the United States from Professor Hilgard, Superintendent of the Coast Survey, and of the United States Department of Weights and Measures. This set was placed in the Institution in accordance with the requirements of the act of Congress of March 3, 1881. (Statutes, XXI, p. 521.)

The set (No. 40) consists of the following:

1. Measure of length: A yard scale divided to inches and tenths, with a matrix for the comparison of end yards.

2. Weights: 25, 10, 5, 5, 2, 2, and 1 pounds; 8, 4, 2, 1, $\frac{1}{2}$, $\frac{1}{4}$, and $\frac{1}{4}$ ounces, and 500, 200, 200, 100, 50, 20, 20, 10, 5, 2, 2, and 1 grains.

3. Capacity measures, liquid: A gallon; a quart; a pint.

4. Capacity measures, dry: A half-bushel; a peck; a half-peck; a quart.

Adjustments: The yard is a line measure and an end measure. The jaws of the matrix forming the latter are given a slight slope.

The yard scale is standard at 56°.8 Fahr.

The bottom of the matrix is standard at 66°.4 Fahr.

The top of the matrix exceeds the bottom by about three hundredths (0.03) inch.

The expansion of the brass scale may be assumed as 0.00036 inch for 1° F.

The weights are so closely adjusted to the standards that any corrections developed in the final comparisons are insensible.

The liquid measures are adjusted to the temperature of 60° F. At this temperature—

The gallon = a standard gallon —0.007 cubic inch.

The quart = a standard quart —0.003 cubic inch.

The pint = a standard pint —0.005 cubic inch.

The dry measures are adjusted to the temperature of the maximum density of water. At this temperature—

The half-bushel = standard —0.009 cubic inch.

The peck = standard +0.007 cubic inch.

The half-peck = standard +0.0003 cubic inch.

The quart = standard +0.002 cubic inch.

In a previous report mention was made of the present by Messrs. Herring & Co., safe manufacturers, of New York City, of a fire-proof safe for the display of precious stones and metals belonging to the National Museum. This safe, which was made, transported to Washington, and placed in the building at the expense entirely of the liberal

donors, is now in the Metallurgical Department, a conspicuous and attractive portion of the Museum.

A very important service has been rendered to the Institution during the year by Capt. Charles Bendire, of the First Cavalry. This officer was detailed on an Army Board, and utilized the opportunity of his abode in Washington for a number of months by completely reorganizing and rearranging the collection of eggs of birds contained in the National Museum. In the course of this operation he presented and interpolated the whole of his own collection of eggs, which was the finest extant, so far as western America is concerned, and well supplied with the species of the Eastern States, as well as those of Europe. Dr. J. C. Merrill, of the Army, was prevailed upon to present his very fine collection, which filled some of the few gaps in Captain Bendire's series.

The National Museum and Smithsonian Institution are not only greatly indebted to Captain Bendire for the donation of one of the most important contributions it has ever received but also for the scientific service rendered and for the accurate identification, labelling, and arrangement, in an extremely attractive and novel manner, of the entire series. The collection is now considered to be in excellent order, and occupies one of the small rooms adjacent to the northeastern pavilion.

Among the desiderata of the National Museum, and one necessary to complete its material for study and exhibition, is that of a collection of plants from the different regions of the globe, and for obtaining which no opportunity has hitherto presented itself. A very satisfactory arrangement was made with Prof. Asa Gray, of Cambridge, to secure the duplicates of what is known as the Joad Herbarium. Mr. Joad was a botanist and much interested in the subject, and, having the means at his command, brought together, in the course of his long life, one of the most extensive private collections of plants known to men of science. This collection went at his death, by bequest, to the Royal Gardens at Kew, London, and as that establishment had the greater number of the species represented on its shelves, it transferred the collection to the Herbarium at Cambridge, Mass. This collection also was nearly complete, and after selecting comparatively few desiderata, Professor Gray, in charge, offered to the Smithsonian Institution the remainder on condition of payment of freight from London, agreeing, at the same time, to attend without cost, to the poisoning of the specimens, their arrangement and proper labelling in suitable portfolios. All this was accomplished at a cost of a little over \$500, and a collection of over 10,000 species is now in the Museum and at the service of students.

At the close, in 1884, of the foreign exhibition held in Boston, which opened in 1883, a large number of exhibits were contributed to the Institution by foreign governments and commercial exhibitors. These, with other donations of greater or less interest, will be noted in the report of Mr. Goode, the assistant director. I may mention here, however, that among the contributions of this character were the greater

part of the exhibits made by Guatemala, Salvador, Ceylon, the Sandwich Islands, &c.

Among other interesting contributions to the Institution has been what purports to be the first flag made in America from American silk. By a formal order of Congress this was transferred to the National Museum, and occupies a satisfactory position therein.

While the Smithsonian Institution is frequently favored by visits of men of science from other countries for the purpose of special inquiry into its methods or as an incident to travel through the country, an unusual throng of such callers was welcomed during the centennial year of 1876, on account of the number connected with the foreign commissions and European visitors generally. A meeting somewhat similar—that of the British Association in Montreal—furnished a great increase over the average, although, while savants of all countries were represented in 1876, the visitors of 1884 were principally Englishmen, who had been in attendance during the meeting of the British Association in Montreal. Several distinguished naturalists took the occasion to study the collections of the National Museum as containing many important types otherwise inaccessible to them.

The Acclimatization Society of Budapest, Austria-Hungary, having made application to the Smithsonian Institution for aid in obtaining a sufficient supply of American hickory nuts for experimental cultivation, through Mr. John Xantus, for many years a highly valued correspondent of the Institution, the matter was referred to Mr. Thomas Meehan, of Germantown, Pa., the well-known florist and pomologist, who attended promptly and satisfactorily to the call.

Within the year a very active organization has been established under the name of the American Ornithologists' Union, having for its object the determination of many points of interest in connection with the migration and history of the birds of North America, which can only be ascertained by a concurrent effort extended over a wide area.

One of the principal objects of this Association has been the preparation of a reliable nomenclature of North American birds. A revision of the previous list, now in progress, will probably be published before long, and will doubtless receive the assent of all working ornithologists.

As it is desirable to ascertain the amount of destruction of birds by striking against light-houses along the coast, with the corresponding indications of dates and routes of migration of the different species, the Union, through its Secretary, Dr. C. Hart Merriam, has issued circulars to the light-houses of the United States and Canada, to be filled up and returned.

An appeal made to the Institution for co-operation was promptly met, the Institution undertaking the expense of printing the blanks and circulars in question, as being strictly germane to its functions. A sufficiently large edition was prepared and transmitted to the Secretary,

and it is understood that important returns have already been received, which, with others, will be duly digested and published.

In the re-organization of the affairs of the National Museum, consequent upon taking possession of the new building, an important place was given for a complete collection of *materia medica* of the whole world, civilized and barbarous, as also for a series of suitable artificial combinations of the elements in nature. In connection with this the services of Dr. J. M. Flint, surgeon, U. S. N., were obtained from the Secretary of the Navy, and the Institution owes everything to the doctor for establishing this collection on a firm basis. Dr. Flint's term having expired, he was transferred to the U. S. Fish Commission steamer "Albatross," and Dr. H. G. Beyer assigned to duty in his place on June 4, 1884. Dr. Beyer has been since that time actively engaged in carrying on the work begun by Dr. Flint, as also initiating some important measures of his own.

When the Chemical Department of the Smithsonian Institution was first organized, Dr. F. M. Endlich was placed in charge, and performed its duties with fidelity and efficiency. On his resignation to take charge of some extensive mining operations in the Southwest, Dr. F. W. Taylor, of Washington, was appointed in his place. The climate of Washington proving too severe for Dr. Taylor's health, he received leave of absence for some months, for the purpose of visiting New Mexico, and on his arrival there, finding that it was in every way to his advantage, he resigned his position in the Institution on June 10, 1884, greatly to our regret. He was succeeded in charge of the laboratory of the Institution by Prof. F. W. Clarke, the chemist of the United States Geological Survey.

UNITED STATES NATIONAL MUSEUM.

A little more than three years ago, in the fall of 1881, the occupancy of the new Museum building was begun, by moving into it several thousand packing boxes full of unassorted and uncatalogued material, the accumulation of many previous years. The members of the Museum staff have been struggling ever since with this fragment of chaos, and it gives me great pleasure to state that at the present time they have finally gained the mastery over it. The material is now under control, and has all been assorted and assigned to its proper departments. Except in a few curatorships, which are not yet entirely organized, the specimens have been catalogued, and are available for study. The preparation of the exhibition series has not yet been completed, however, owing to the necessary delays in the work of printing the labels and making the exhibition cases. Two things have interfered materially with the progress of the work: first, the tremendous influx of new material, which has required immediate attention to insure its safety, 3,509 packages having been received during the year; and, second, the

interruptions caused by the preparations for the exhibitions in London, New Orleans, Louisville, and Cincinnati, which have really put back the work of arranging the collections at least twelve months.

It must be remembered that the "National Museum" is actually an institution of very recent origin, although the *idea* of the National Museum has been in process of development for very many years. As recently as 1877 the appropriation made by Congress for its support was only $10,000. The "National Museum" was not recognized by that name in the Congressional appropriation bills until 1876, although the term was used in the reports of the Secretary of the Smithsonian Institution as early as 1868,* and although the national collections were transferred to the custody of the Institution in 1858, in accordance with the act of incorporation passed in 1846, by which it is provided that, "all objects of art and of foreign and curious research, and all objects of natural history, plants, and geological and mineralogical specimens belonging or hereafter to belong to the United States, which may be in the city of Washington," shall be delivered to the Regents of the Smithsonian Institution, and, together with new specimens obtained by exchange, donation, or otherwise, shall be so arranged and classified as best to facilitate their examination and study.†

Nearly half a century has passed since the United States, by the provisions of the will of James Smithson, first became proprietor of a scientific collection, in the shape of the Smithson minerals and meteorites; it is forty-three years since the National Institute was founded, with great prestige and influence, for the avowed purpose of organizing a National Museum of Natural History; thirty-eight since Congress threw upon the Regents of the Smithsonian Institution the responsibility of caring for the so-called "National Cabinet of Curiosities;" twenty-seven since this responsibility was finally accepted and these collections were transferred to the Smithsonian building; thirty-five since the Institution began to make collections of its own; eight since Congress has really recognized the "National Museum" as its ward, and four since the Museum has had a shelter of its own, and an appropriation in any way adequate to the necessities of its administrative work. The year 1880, then, marks an epoch in the history of the Museum, since at this time Congress saw fit to recognize the claims of the Museum by increasing the appropriations for its preservation and installation from $34,500 to $135,000.

Their responsibility in the matter they had, however, recognized in 1879, by appropriating $250,000 for the construction of a fire-proof building. The claims of the Museum to increased support had been

* See Report Smithsonian Institution, 1867, p. 55.

† An act to establish the "Smithsonian Institution" for the increase and diffusion of useful knowledge among men. (Approved August 10, 1846; Revised Statutes, title lxxiii, sections 5579–5594.) See also Revised Statutes, section 5586, and Statutes Forty-fifth Congress, third session, chap. 182, p. 394.

before them for three or four years—ever since, indeed, by their own act, in connection with the preparations for the participation of the Government Departments in the International Exposition in Philadelphia, and the valuable gifts of foreign Governments upon that occasion, the Smithsonian building had been filled to overflowing with unassorted material of the highest value for educational and scientific uses. These facts should be borne in mind in considering the present condition of the Museum, which is really—thanks to a large and efficient staff of curators—in much better condition than a glance at the exhibition halls would seem to indicate.

If Congress continues its present policy in making appropriations for the coming fiscal year I shall be able to report at your next meeting that the exhibition series of specimens is in nearly as good condition as the study series—which is not now the case, for it has been our policy to work from the foundation upwards and to get the great mass of the reserve collections into good condition, before attempting to prepare the selected series of specimens for display in the open cases.

More than ten years ago*—as Assistant Secretary—I pointed out in my report to the Secretary of the Institution that the annual growth of the Museum was undoubtedly greater than that of any other in the world; that is, so far as the accession of great masses of material was concerned. The increase at present is much greater than formerly, but the accessions are much more manageable, owing to the larger number of assistants employed. For twenty years the Assistant Secretary of the Smithsonian Institution, with the help of one or two laborers and such students as happened to volunteer their aid, performed all the duties of curatorship of the national collections. It was not until 1874 that a special staff of Museum assistants was recognized, with duties apart from the executive work of the Institution, and not until 1875 that the office of curator was established, that office being held by the Assistant Secretary from 1875 to 1878. Up to 1880 there was still but one curator, with a number of "assistants," but during that year an executive officer, with the grade of assistant director, was appointed, and the five principal assistants in the Museum were designated curators. The present organization of the *personnel*, then, dates back only five years, to the time when preparations were being made for taking possession of the new building.

The staff, as now organized, consists of two classes—the scientific officers, or curators, and the administrative officers; the former reporting to the director of the Museum, the latter to the assistant director, who also has general supervision of the administrative work of the curators.

There are at present 19 curatorships, some of which are divided as indicated below, so that the number of heads of departments or subdepartments is 25, and the total number of men in the scientific staff

* Smithsonian Report for 1873, p. 49.

36, of whom 24 are in the pay of the Museum, and the others are honorary, 5 being detailed for this duty by the director of the Geological Survey, 1 by the director of the Bureau of Ethnology, others by the Commission of Fisheries, and by the Secretary of the Navy, two being volunteers. It may be stated here that these details are in every instance made in the interests of co-operation by those bureaus of the Government engaged in work closely connected with that of the Museum. The paleontologists of the Geological Survey find it so much to their advantage to have access to the paleontological collections of the Museum, and the use of the laboratories, storage cases, and general administrative machinery of the Museum, that they are permitted by their chief to assume the responsibilities of curatorships and perform a general work of supervision. In the same way it is with the mineralogist and the ethnologist detailed. In nearly every case, however, the Museum supplies the honorary curators with assistants, who relieve them of much of the routine work. The curatorships are now organized as follows:

I. *Arts and Industries.*—The Assistant Director acting as curator, with sub-curatorships as follows: A. Howard Clark, assistant; two preparators.

a. Materia medica: Dr. H. G. Beyer, U. S. N., honorary curator, with one clerk.

b. Textile industries: Romyn Hitchcock, acting curator.

c. Fisheries: R. Edward Earll, curator.

d. Animal products: R. Edward Earll, acting curator.

e. Naval architecture: Capt. J. W. Collins, United States Fish Commission, honorary curator.

f. Foods: W. O. Atwater, acting curator.

In this department, it may be stated, is administered very much of the material usually arranged by museums in their ethnological series, and the curator of ethnology is consequently acting as adjunct curator in arts and industries.

II. *Ethnology.*—Dr. Otis T. Mason, curator, with one preparator and two clerks.

III. *Antiquities.*—Dr. Charles Rau, curator; E. P. Upham, assistant.

IV. *American Prehistoric Pottery.*—W. H. Holmes, Bureau of Ethnology, honorary curator; Dr. Edward Foreman, assistant; one preparator.

V. *Mammals.*—Frederick W. True, curator; one clerk; two preparators.

VI. *Birds.*—Robert Ridgway, curator; Dr. Leonard Stejneger, assistant; one clerk and one preparator.

VII. *Birds' Eggs.*—Capt. Charles Bendire, U. S. A., honorary curator (volunteer), and one clerk.

VIII. *Reptiles and Batrachians.*—Dr. H. C. Yarrow, honorary curator (volunteer).

IX. *Fishes.*—Dr. Tarleton H. Bean, curator; Peter Parker and B. A. Bean, assistants, detailed from United States Fish Commission.

X. *Comparative Anatomy.*—Frederick W. True, curator; F. A. Lucas assistant; one preparator.

XI. *Mollusks.*—W. H. Dall, United States Geological Survey, curator; Dr. R. E. C. Stearns, adjunct curator; one clerk.

XII. *Insects.*—Dr. C. V. Riley, honorary curator (volunteer).

XIII. *Marine Invertebrates.*—Richard Rathbun, curator; L. H. Baldwin, assistant, and one clerk detailed by the United States Fish Commission.

XIV. *Invertebrate Fossils, Paleozic.*—C. D. Walcott, United States Geological Survey, honorary curator.

XV. *Invertebrate Fossils, Mesozoic and Cenozoic.*—Dr. C. A. White, United States Geological Survey, honorary curator; J. B. Marcou, United States Geological Survey, honorary assistant.

XVI. *Plants, Fossil and Recent.*—Lester F. Ward, United States Geological Survey, honorary curator; one clerk; one preparator.

XVII. *Mineralogy.*—Dr. F. W. Clarke, United States Geological Survey, honorary curator; W. S. Yeates, assistant.

XVIII. *Lithology and Physical Geology.*—George P. Merrill, acting curator; one preparator.

XIX. *Metallurgy and Economic Geology.*—Fred. P. Dewey, curator; J. A. Allen, assistant.

Division of Administration.

The Division of Administration consists of fifteen departments, the organization of which has been described at length in previous reports. A number of additional preparators have been employed for special work upon the collections for the New Orleans Exposition, and an unusual quantity of objects for the exhibition series has been completed during the year in the workshops, as is shown in the review of the operations of the scientific departments. Specially noteworthy among these is a number of gigantic photographic enlargements representing thirteen of the Government buildings in Washington. These are the largest prints ever made, and have been found particularly effective at New Orleans and Cincinnati, it being thought that in an exhibition of the work of the Government Departments, such as has been attempted this year by the United States Executive Board, it was particularly appropriate that the public buildings of Washington should be shown in an impressive manner.

In addition to the regular administrative staff of the Museum, an administrative staff for exhibition work has been maintained since July, 1882, under the general charge of the Assistant Director. Mr. R. Edward Earll is the executive officer, and Mr. W. V. Cox financial clerk of this staff, which is increased from time to time as occasion requires by the employment of extra clerks and preparators, and to which also, when

necessary, are detailed various officers of the Museum scientific staff. In addition to the exhibition work of the year elsewhere referred to, this staff is still engaged in the preparation of a report upon the International Fisheries Exhibition at London.

Department of Ethnology.—Prof. Otis T. Mason, having been appointed curator, took charge of this department on the 1st of July and spent the remainder of the year chiefly in getting control of his material. All of the ethnological specimens of the Museum are now under complete management, a part of them being on exhibition, the remainder classified and stored in drawers for ready reference. During the year, 3,658 specimens belonging to primitive races have been received. In addition to these, this department has been intrusted with many objects registered in other catalogues and deposited here for the sake of completing evolutionary series of implements, processes, and art products. The most noteworthy accessions in 1884 were as follows: Illustrations of Eskimo and Indian life from Ungava Bay and vicinity, by Lucien M. Turner, who will prepare a monograph upon the specimens; illustrations of Eskimo life at Point Barrow, collected by Lieutenant Ray, U. S. A. Mr. Murdoch will describe these: rich collections from the Eskimo of Western and Southern Alaska, by E. W. Nelson, W. J. Fisher, Charles L. McKay, Baron Nordenskiold; specimens of the arts of the tribes of Northwest America, collected by J. G. Swan and Lieut. T. Dix Bolles; many objects illustrative of the modern Indians of Yucatan, by Louis H. Ayme; a very large and instructive collection of objects from the Peruvian huacas, by George W. Keifer and Dr. William H. Jones, U. S. N.; a collection of weapons, &c., from New Guinea, purchased from A. P. Goodwin; an exchange series of weapons from Polynesia, contributed by Charles Heape. During the year illustrative series of ethnological objects have been exhibited at Cincinnati, Louisville, and New Orleans, care being taken in each case to impress some ethnological truth, such as distribution of types, the effect of environment, the treatment of the same art by different tribes, or the progress of an art from its infancy to its highest manifestation.

Department of Antiquities.—Dr. Rau reports 3,956 specimens added to the exhibition and study series and 1,185 to the duplicates. They are in numerous accession lots, of which 18 were sufficiently important to merit especial notice. An extensive educational series, illustrating American archæology, was prepared for the New Orleans Exposition. The collection now comprises 45,252 specimens, of which 8,522 are in the duplicate bins.

Department of Mammals.—Notwithstanding the absence of the curator, Mr. True, in Europe during the first quarter of the year, and other diversions of his attention and time to routine work not connected with his regular duties, the progress of this department has been exceedingly satisfactory. The work upon the exhibition series has been hampered by the fact that money was not available for the construction of the desired

cases in the mammal hall. The collection is now, for the first time in many years, thoroughly classified and under control, and the total number of skins and alcoholic specimens is reported to be 5,694, and of skulls and skeletons 4,214, making a total of 9,908. The accessions of the year have, in number, variety, and importance, been fully equal to those of earlier periods. No less than 38 specimens, including such rare and peculiar forms as the eland, harnessed-antelope, cheetah, two species of lemur, wart-hog, and baboons, have been received from the proprietors of zoological gardens and menageries, for which due acknowledgments are made in the Museum report. An unusual number of cetaceans and seals, many of great novelty and interest, have come in from various sources. The amount of taxidermic work accomplished has been unusually great, owing to a special allotment for the employment of extra help, made from the appropriation for the New Orleans Exhibition—149 specimens in all having been added to the mounted series, including several large forms, such as the buffalo, puma, jaguar, and beaver.

Department of Birds.—Mr. Ridgway reports that the year has been unprecedented in the extent of the accessions and the amount of work accomplished. The number of birds added during the year is 8,142, 2,658 having been distributed. The collections have been entirely rearranged and the exhibition series is receiving a complete overhauling. Over 1,200 skins have been mounted, and copy for 1,000 species labels have been sent to the printer. The total number of specimens in the reserve series is now 50,350, 6,800 of which are in the exhibition series. Very much of the increased activity of the year was due to the stimulus of preparation for the New Orleans Exhibition and the aid received from this appropriation. About 500 birds were sent to New Orleans, constituting a complete representation of American game birds.

Department of Birds' Eggs.—During the year the collections have been overhauled and thoroughly rearranged by Capt. Charles Bendire, U. S. A., who has incorporated with it his own collection, including nearly 8,000 specimens, the finest in the United States, which he has presented to the Museum. This collection now represents pretty nearly all that is known of American oölogy, and contains 40,072 specimens, of which 4,272 are foreign.

Department of Reptiles and Batrachians.—Comparatively little has been done in this department, owing to the absence of Dr. Yarrow on a collecting expedition in Utah during the summer months, which he has in former years devoted to volunteer work upon the collections.

Department of Fishes.—The work upon this great collection has made fine progress during the year. The curator, Dr. Bean, has nearly completed his card catalogue of the reserve series, and during the summer Prof. D. S. Jordan was employed, in the interest of the New Orleans Exhibition, in selecting a special exhibition series to include all the fresh-water fishes of the United States, and to make a special collect-

ing trip through the Mississippi Valley, with the view to supply such species as were lacking in the collection. This trip has been of great importance to the science of ichthyology, bringing to light very many important facts concerning the fishes of a region not previously explored ichthyologically, and throwing much light upon the whole subject of distribution. Out of the 560 fresh-water species known to inhabit North America, the Museum now has all but 49, 30 having been added by this trip, and some 25 new species having been brought to light. The accessions to this department have been very important, especially those from the Fish Commission; at least twenty new fishes from the deep-sea fauna having been brought in as a result of the work of the Albatross.

Department of Comparative Anatomy.—A department of comparative anatomy is being organized, and the east-south range has been filled up with a very beautiful set of cases, especially constructed for the reception of the preparations. Mr. Lucas, with his two assistants, has been engaged, during the latter part of the year, in mounting skeletons, and fully 150 fine preparations have been put on exhibition. The report of Mr. True upon the plan of organization will not be presented until next year, since much preparatory work remains to be done. A case illustrating the work in this department was sent to the New Orleans Exposition.

Department of Mollusks.—Mr. W. H. Dall, who has for many years had charge of the collection of mollusks, having been appointed one of the palæontologists of the Geological Survey, and assigned to the department of Quaternary mollusks, has, by the request of the Director of the Survey, been assigned working rooms in the Smithsonian building, and will continue to care for the department as heretofore, access to the collections of recent shells being necessary for comparison with the shells of the Quaternary beds, which are, for the most part, specifically identical. Prof. R. E. C. Stearns, late of the University of California, has been assigned to this department as adjunct curator, and since the first of July there has been great activity in rearranging the collections. It was decided to make an extensive display of the mollusks of the United States at the New Orleans Exposition, and the well-known Stearns collection of mollusks, for which negotiations had been in progress for some years, was purchased from the exhibition appropriation. Dr. Stearns had in charge the preparation of the series for New Orleans, which occupied his time from July until the end of the year. This occupied twenty large cases, and exhibits the economic mollusks of both coasts and the adjacent seas, and the fresh-water mussels, which form so remarkable a part of the fauna of the great Mississippi basin. Mr. R. Ellsworth Call has been employed for six months in connection with the New Orleans work, and by the efforts of these three conchologists, with the help of two clerks, much progress has been made toward getting under final control the immense mass of material in this department.

Department of Insects.—Prof. C. V. Riley has, as in previous years, voluntarily assumed the care of the entomological material which has come in, and his own valuable and constantly increasing collection remains a deposit in the Museum. A collection of insects injurious to forest trees, mounted in Museum cases, in the style which it is proposed by Professor Riley to adopt in the arrangement of our exhibition series when the opportunity comes, was sent to the International Forestry Exhibition in Edinburgh and received a gold medal. Fifty-five accession lots were received during the year, the most valuable being the collection made by L. M. Turner at Ungava Bay, H. B. T. It is hoped that the financial condition of the Museum will soon warrant the placing of this very important and long-neglected department upon a footing of equality with the others.

Department of Marine Invertebrates.—In the Department of Marine Invertebrates, exclusive of the Mollusca, under the charge of Mr. Rathbun, 240 cases of specimens, enumerated in 72 accessions, have been added during the year. Of these, the most important have been received from the United States Fish Commission, from Dr. Edward Palmer, a collector employed in the interest of the New Orleans Exhibition, and from various naval sources. The Fish Commission collections are mainly illustrative of the recent deep-sea explorations of the steamer "Albatross" off the eastern coast of the United States and in the Gulf of Mexico and Caribbean Sea, and contain many new additions to science, which have been worked up only in part. They fill several thousand jars and vials. The collection of Dr. Palmer was made for the purpose of representing at the World's Fair, in New Orleans, the varied animal resources of the coral reef and sponge regions of Southern and Western Florida. It consisted for the most part of finely prepared specimens of commercial and other sponges, ornamental corals, and the larger species of Crustaceans and Mollusks used as food, and required 65 large shipping cases to transport it to Washington. Supplemental to this is an extensive collection made by Mr. Henry Hemphill on the western coast of Florida.

Among the more interesting of the naval contributions are several collections of Crustaceans and Echinoderms, obtained by Dr. W. H. Jones, U. S. N., in different parts of the Pacific Ocean. A number of valuable collections, carefully identified, have also been received from competent European authorities, and will be of great service in the elaboration of new materials contained in the Museum.

The increase of accessions to this department has been so great during the year, especially by reason of the material furnished by the Fish Commission, that, even with the aid of three or four assistants, little more could be done than to take care of the new material.

Department of Invertebrate Fossils (Paleozoic).—The collections of this department are arranged in 13 unit table cases and in office trays equivalent in capacity to as many more. Mr. Walcott estimates the total num-

ber of specimens at 25,000, including the old Smithsonian collections and the accessions from the recent Government surveys and other sources up to the present time. The most important accession of the year is that of Devonian and Carboniferous fossils from the United States Geological Survey, many of them types of new species, and forming the basis of Mr. Walcott's recent "Paleontology of the Eureka District, Nevada."

Department of Invertebrate Fossils (Mesozoic and Cenozoic).—The accessions of the year consist of 85 boxes from the Geological Survey, embracing collections made in California, Oregon, New Jersey, Florida, Alabama, and Mississippi, and 15 miscellaneous lots sent from private sources to the Museum. The catalogue entries number 1,158. From this department, as from many others, there comes a request for more room. These requests we are striving to grant as rapidly as the appropriation for the construction of cases will allow, but it is doubtful if the necessities of the case can be fully met until a new building can be put up.

Department of Plants, Fossil and Recent.—The collection of fossil plants now contains 923 distinct species identified and installed. The report of Professor Ward contains elaborate statistics of the collection, from which it appears that 7,291 specimens have already been catalogued. The accessions of the year have been of but slight importance. The Joad collection of recent plants has not yet been unpacked, owing to lack of room, but will soon be arranged and in proper condition for study. During the year Mr. William R. Smith, superintendent of the Government Botanic Garden, has placed in the rotunda of the new building a number of very beautiful palms, which add very much to the attractiveness of the apartment, and which, being selected with reference to their economic importance to man, will, when labeled, furnish instruction as well as pleasure to the visitors.

Department of Lithology and Physical Geology.—Mr. Merrill reports a total number of entries amounting to 2,541, including not less than 3,000 specimens administered upon during the year. Prominent among the accessions is a series of rocks and tufas from Utah, Nevada, and California, collected by Mr. I. C. Russell and transferred by the Geological Survey, and a large collection of building stones from John S. F. Batchen. Mr. Merrill prepared a large and important series of specimens for the New Orleans Exhibition, and in this work had the efficient assistance of Mr. L. H. Merrill, and the services of a number of stone-cutters for some months.

Some remarkably beautiful colored photographic enlargements on glass, illustrating the structure of twelve selected types of rocks, were among the most striking products of the year's work in Mr. Merrill's laboratory; also a series of colored sketches showing the appearance of various kinds of building stones used in architectural work. The collections sent to New Orleans included a type collection of the building

and ornamental stones of the United States, comprising 358 specimens, an educational series of rocks, containing 500 specimens, a very interesting structural series of rocks, and a collection of rock-forming minerals. In addition to all this work, 1,557 descriptive labels were printed and 200 thin sections of rock prepared. The collection as it now stands is described by Mr. Merrill as follows:

The total number of specimens in the reserve series is not less than 15,000, of which some 3,000 are now on exhibition. Of these, 4,246 are building or ornamental stones, 1,658 of which are on exhibition. The number of specimens in the duplicate series will probably increase the total to 18,000.

Department of Minerals.—Prof. F. W. Clarke, chief chemist of the Geological Survey, continues to act as curator, Mr. W. S. Yeates having the collections in immediate charge. During the year, the growth of the collections has been steady and encouraging, the work of installing the collections has been definitely begun, and a system of exchanges has been fairly inaugurated. Mr. Joseph Willcox has deposited his private collection, consisting of some 1,400 specimens, which is, in some respects, one of the finest in America. Mr. J. T. Abert has given the valuable collection of his father, Col. J. J. Abert, containing 1,245 specimens. An allotment of $2,500 from the New Orleans appropriation was devoted to building up the collection of gems and ornamental stones. The schedule adopted included all the gems proper, rock crystal, agates and jaspers, malachite, *lapis lazuli*, &c., and every important gem or ornamental species was secured both in the rough and cut conditions. About 1,000 specimens are on exhibition at New Orleans, of which nearly one-third are cut and polished stones. A part of this collection was exhibited at Cincinnati, where it was awarded a silver medal. In connection with the New Orleans work, two important collecting trips were made by Mr. Yeates, to Northern New York and the Hot Springs of Arkansas. The total number of specimens in the collection is estimated at 15,288.

Department of Metallurgy.—Owing to the absence of Mr. Dewey in New Orleans, no report upon his work can be given. It may be stated, however, that a large force has been at work during the entire year, with very satisfactory results in the way of reducing to order the great mass of material, the accumulation of many years. Since July, Mr. Dewey and his staff have been preparing the New Orleans collection, having an allotment of $5,000 wherewith to illustrate the metallic resources of the country, and, by the aid of a number of volunteer assistants in the field, the collection has received accessions of very great value, which make it one of the most important metallurgical collections in the world.

Increase of the Museum.—The accessions are described in detail in the reports of the Assistant Director and Curators of the Museum, and are

also referred to in the discussion of the explorations carried on during the year by the Smithsonian and affiliated organizations.

Exposition Work.—The participation of the Smithsonian Institution, as directed by Congress in three exhibitions, has, although in many respects detrimental to the growth of the Museum, contributed largely to the prosperity of several of its departments. In the first place, in order that material might properly be selected for exhibition, it was found necessary in many departments of the Museum to employ additional assistants in making a thorough overhauling of the material and getting it systematically arranged. In the second place, it was found necessary to purchase a considerable amount of material to fill vacancies in the various series of specimens which were shown at the exhibitions. It has been our policy to expend the appropriation for the New Orleans Exposition in such a manner that there also might result a permanent benefit to the Museum. This we have found to be entirely consistent with the interests of the exhibitions, since the material which is useful for these temporary displays is even more useful for the permanent exhibition series of the Museum. At the same time, in many of the departments, an effort has been made in selecting specimens for the expositions, to make use of duplicate material from the Museum, in order that, should we be called upon in future to participate in other exhibitions, the preparation of a collection can be effected with less expense of time and money than has been heretofore practicable.

I can, at present, only present a brief preliminary report upon what has been done in connection with the exhibitions at Cincinnati, Louisville, and New Orleans.

By direction of Congress the Smithsonian Institution, in connection with the Executive Departments of the Government and the Department of Agriculture, has taken part during the year in three industrial exhibitions—the "Cincinnati Industrial Exposition," at Cincinnati, open from September 3 to October 4; the "Southern Exposition," at Louisville, open from August 16 to October 25, and the "World's Industrial and Cotton Centennial Exposition," at New Orleans, which opened on December 16, and will not close until June 30 of the present year. Out of $300,000 appropriated to the Government executive board for the New Orleans Exhibition, the Smithsonian received $75,000, and of the $10,000 for the boards participating at Louisville, and a like sum for Cincinnati, the allotment to the Smithsonian was $5,000—$2,500 for Louisville and $2,300 for Cincinnati. The conduct of the displays on the part of the Government was intrusted to an executive board appointed by the President of the United States, of which Col. S. C. Lyford, U. S. A., was designated president. Mr. G. Brown Goode was nominated by me and appointed by the President member of this board on behalf of the Smithsonian Institution, National Museum, and Fish Commission.

The passing of the appropriation bill was so long delayed that when the money finally became available, only two weeks' time remained be-

fore it was necessary to have the collections for Louisville packed and on the way. We were, therefore, unable to make a very extensive exhibit at that place.

The special features of the exhibit were a large collection showing the uses of animals, a collection of textile fibers and fabrics, a series of the game and water birds of North America, a small collection of boat models, including the whale-boat and the Chinese junk, a collection of casts of reptiles, and a large number of photographs illustrative of the methods employed in the fisheries.

The exhibit was packed in ninety-six boxes of various sizes.

The Cincinnati Exposition opened two weeks later, and it was therefore possible to make a more creditable display. A special building was erected for the Government exhibit, one end of which was assigned to the Smithsonian Institution. In addition to a collection similar to that sent to Louisville there was prepared for the Cincinnati Exposition a fine collection of gems, and also an exhibit representative of the ethnology of the North American Indians and Eskimos. Several large casts of cetaceans were also displayed.

It was found necessary to have most of the Louisville and Cincinnati collections returned to Washington to be prepared and rearranged before sending them to New Orleans.

By virtue of an Executive order of May 13, 1884, a board, consisting of a representative of each Government Department and of the Smithsonian Institution, was appointed and charged with making arrangements for a display of collections illustrating the resources of the United States at the World's Industrial and Cotton Centennial Exposition to be held at New Orleans. The appropriations for this purpose were not made until July 7, leaving only four clear months for the preparation and shipment of collections. Several of the curators were at once sent into the field with the authority to add to the collections under their charge. By December 1, the collections were ready for transmission, but the opening had been deferred from December 1 to December 16. On this date the Exposition was formally opened.

The preparations for this Exposition were very much more elaborate than had been possible in the case of the Louisville and Cincinnati Expositions. The main feature of the display made by the Institution at New Orleans was, of course, understood to be in illustration of the animal and mineral resources and the ethnology of the United States, similar to that made by the Institution in 1876 at Philadelphia. In addition to this a collection illustrating the textile industries of the world was prepared, in view of the fact that the main interest of the New Orleans Exposition centered in one of the textile materials, and also a selection of objects from the Department of Naval Architecture. The curators of eleven departments were requested to take part in the preparation of the New Orleans exhibit, and most of them were tempo-

rarily placed upon the exhibition staff. The character of the work undertaken by them may be briefly sketched as follows:

The participation of the Zoological and Geological Departments has been referred to in the review of the work of the several departments, and will not be repeated here.

Department of Arts and Industries.—Mr. Romyn Hitchcock undertook the preparation of a collection of textile fibers and fabrics. Portions of this collection were exhibited both at Louisville and Cincinnati. Capt. J. W. Collins prepared a series of working models illustrating the development of the ship-building industry in the United States, and especially the evolution of the American schooner, the American pilot-boat, and the American cotton-ship. A number of full-rigged models were also sent in this connection, being exhibited on the way at Louisville and Cincinnati. The model of a whale-boat, fully equipped with all appliances for the capture of whales, was also sent. This model attracted much attention at the London and Berlin Fisheries Exhibitions.

The animal products collection, which was so prominent a feature in our exhibition at Philadelphia, was reorganized and greatly extended, so that it now represents very thoroughly the applications of animals to the uses of mankind in all parts of the world. This collection alone, if arranged in table-cases, would occupy a floor space equivalent to that in one of the large halls of the new Museum building. The Museum has received many important gifts for this collection on condition that they be exhibited in New Orleans before being finally placed in the Museum.

The Section of Fisheries was represented by about sixty of the large pictures prepared for the London Exhibition, and by about two hundred casts of American food fishes, which also had direct relation to the animal products collection just referred to. It was not deemed expedient to dismantle the general fishery collections so recently installed, for such a temporary interest as that of these exhibitions. The United States Fish Commission made preparations for a considerable display of fish-culture, and a representative collection of fish-cultural apparatus was sent from the Museum.

A selection of about two hundred and fifty of the celebrated autotypes published by Adolph Braun & Co., of Dornach, was acquired for display. This collection illustrates the history of painting from the time of Cimabue and Giotto, including from one to six copies of the best representative works of each celebrated master, so far as it was practicable to obtain them. This collection can be packed in a very small space, and is particularly well suited for sending away to exhibitions. It may in the future be somewhat extended to very good advantage.

Department of Ethnology.—There were sent to New Orleans about two hundred and fifty unit boxes, containing a representative collection of American ethnological objects. These were very largely selected from the duplicates in the Museum and are available for future exhibition.

Number of visitors to the United States National Museum and Smithsonian Institution for 1882, 1883, and 1884.

Year.	Museum building.	Smithsonian building.
1881	*150,000	....
1882	†167,455	152,744
1883	202,188	104,823
1884	195,322	91,130

* Estimated on basis of register.
† Estimated on basis of from February 8 to December 31.

Meetings in the Lecture-Hall.—The lecture-hall of the National Museum has been used during the year for sixty-eight meetings of various characters, as is shown below.

National Academy of Sciences.—April 15–April 17. Ten meetings were held. On the evening of the 17th a public meeting was held, at which the eulogies of deceased members were pronounced, 176 persons being in attendance.

American Surgical Association.—April 30–May 3. Eight meetings were held.

American Fish-Cultural Association.—May 13–May 13. Seven meetings were held. On the evening of May 13 a public meeting took place, Hon. Elbridge G. Lapham in the chair. The address was delivered by Hon. Theodore Lyman, of Massachusetts, who was followed by Hon. S. S. Cox, of New York. About 350 people were present.

American Dental Association.—July 22–July 23. Four meetings were held.

Society of American Taxidermists.—July 30. One meeting was held.

Society of Naturalists of the Eastern United States.—December 29–December 30. Four meetings were held.

The Biological Society of Washington.—Fortnightly meetings were held between January 25 and May 31 and between November 1 and December 27. In all there were fifteen meetings.

The Entomological Society of Washington held three meetings in the office of the Assistant Director, on May 8, June 3, and November 3, respectively.

Saturday Lectures.—Four courses of these lectures were given, consisting of seventeen lectures, a list of which is subjoined:

January 5. Mr. Grove K. Gilbert, Cliffs and Terraces.

January 12. Prof. Otis T. Mason, Child Life among Savage and Uncivilized Peoples.

January 19. Prof. Edward S. Morse, Social Life among the Japanese.

January 26. Maj. J. W. Powell, Win-tun Mythology.

February 2. Prof. F. W. Clarke, Lightning and Lightning Rods.

February 9. Capt. C. E. Dutton, U. S. A., The Hawaiian Islands and People.

February 18. Prof. John Murdoch, Eskimo Life at Point Barrow.

February 23. Prof. Harvey W. Wiley, The Sugar Industry of the North.

March 1. Prof. Harvey W. Wiley, The Sugar Industry of the North.

March 8. Prof. Simon Newcomb, Psychic Force.

March 15. Mr. John A. Ryder, Protoplasm in the Light of Recent Investigations.

March 22. Dr. Frank Baker, The New Phrenology.

March 29. Dr. D. Webster Prentiss, The Bird Life of the District of Columbia.

April 5. Prof. T. C. Chamberlin, The Great Ice Invasion of North America.

April 12. Dr. W. W. Godding, What shall we do with the Inebriates?

April 19. Prof. J. S. Newberry, The Industrial Arts as Factors in Modern History.

April 26. Maj. J. W. Powell, The Cañons of the Colorado.

BUREAU OF ETHNOLOGY.

The prosecution of ethnologic researches among the North American Indians, under the direction of the Secretary of the Smithsonian Institution and in compliance with act of Congress, was continued during the year 1884, under the charge of Maj. J. W. Powell, who has furnished the following account of operations.

They may be conveniently reported upon under the two general heads of Field Work and Office Work, the latter to a large extent being the supplement to and discussion of the former, and executed by the same officers, who had previously obtained materials and information in the field.

1. *Field Work.*

This heading may be divided into, 1st, Mound Explorations; 2d, Collections from Ancient and Modern Stone Villages; and, 3d, General Field Studies, embracing those in Institutions, Linguistics, and other divisions of Anthropology.

Mound Explorations.—The work of exploring the mounds and other ancient monuments of our country, begun in 1882, was carried on during the year 1884, under the charge of Prof. Cyrus Thomas.

The same persons, viz, Mr. P. W. Norris, Mr. James D. Middleton, and Dr. Edward Palmer, who had been engaged during the previous year, were retained as the regular field assistants, but Dr. Palmer ceased to be connected with the work after the 30th of June, being then succeeded by Mr. John P. Rogan.

Mr. Norris was engaged during the latter part of the winter and most of the spring in Arkansas, then returned to Kanawha Valley, West Virginia, where he was occupied in exploring the extensive group of works in the vicinity of Charleston until December, when he was compelled by the cold weather and sickness to desist. To the great regret of all his associates in the work, his sickness terminated in death a few days after the close of the year. By his death the division has lost a faithful and enthusiastic worker.

His explorations in Kanawha Valley brought to light the fact that here is one of the most extensive and interesting groups of works in the United States. Although the exploration of this group is not yet complete, it is sufficient to demonstrate beyond reasonable doubt that the people who constructed the works of this locality built the Grave Creek mound, or were intimately related to the authors of that noted tumulus. There are also found some strong indications that they were related to the authors of the ancient works of the Scioto Valley.

Mr. Middleton continued operations in Arkansas until the approach of summer, assisted for some of the time by Mr. L. H. Thing. During the remainder of the summer, the fall months, and until the approach of extreme cold weather, he was engaged in exploring the works of Knox County, Ohio. Since that time his field of operations has been Arkansas.

Dr. Palmer was engaged, during the six months of the year he remained with the division, chiefly in Alabama, and in Early County, Georgia.

Previous to his appointment as permanent assistant Mr. Rogan was employed in Northern Georgia, principally in exploring the celebrated Etowah group in Bartow County. This examination brought to light some of the most remarkable mound relics so far discovered in the United States. These consist of very thin, evenly wrought sheets of copper, on which are impressed, as regularly as though done with metallic dies or by means of machinery, figures bearing strong resemblance to the Mexican and Central American designs. The conditions under which these were found leave no doubt that they were placed in the mounds when they were built, and not subsequently. Here also was found part of a stone bust of nearly life size, and the broken arm of another stone image, also but little less than life size.

During the latter part of the summer and until the beginning of winter, Mr. Rogan was engaged, in connection with the Rev. J. P. MacLean, in examining and exploring the ancient monuments of Butler County and adjacent regions of Southern Ohio.

Mr. Charles Smith was employed during the month of November in examining the ancient quarries of "Flint Ridge," Ohio, and making collections to illustrate the various stages in the aboriginal manufacture of flint implements. The collection made is, perhaps, the most com-

plete in this particular line of any single one so far made in this country.

During the year nearly five thousand specimens were collected. The data obtained bearing on the questions relating to the origin and uses of the ancient monuments of North America, and the habits, customs, and culture-status of the people who constructed them, are very important, and will throw much additional light on these interesting problems. The number of whole and uninjured vessels of clay collected by Messrs. Middleton, Thing, and Norris is much larger than that of the preceding year, and is very valuable on account of the new and unusual types obtained. The collection of copper implements and ornaments is also large and valuable.

Although the pottery obtained by Dr. Palmer in Early County, Georgia, is in fragments, it is of special value, as it serves, when compared with that of the region of Flint River and other sections, to show that this southern region was occupied by a people varying, in some respects at least, from those of the other portions of the South.

Collections from Stone Villages.—Ethnologic and archæologic researches among the Pueblo Indians, and ancient ruins in the southwestern Territories, were extensively prosecuted during the year. Mr. James Stevenson, in charge of a party, proceeded to Arizona and New Mexico to examine special localities and make collections of objects illustrating the arts and industries of the Indian tribes of that region. The labors of this party resulted in a collection of about eight thousand five hundred specimens of pottery, stone, and other domestic implements, both ancient and modern, representing nearly all phases of life, art, and industry among those tribes. A portion of Mr. Stevenson's party, in charge of Mr. F. D. Beckford, made explorations among the ruins of Chaco Cañon in Northwestern New Mexico, Cañon de Chelly and some of its branches, the cliff dwellings in Walnut Cañon in Arizona, and a group of cave dwellings near Flagstaff in the same Territory, the results of which are full notes, sketches, and photographic illustrations of the ruins examined. The remainder of this party was divided; one party was stationed at the pueblo of Acoma, in charge of Mr. Garlick, and the other at Zuñi in New Mexico. The party at Acoma made a collection of about three thousand five hundred specimens, consisting of pottery and domestic utensils of other material, such as stone, hoca, bone, wood, and woven fabrics. The collection from the pueblo of Acoma, though not embracing so great a variety of objects, will, however, illustrate nearly all the phases of the arts and industrial pursuits of those Indians.

The collection made at Zuñi, under Mr. Stevenson's personal supervision, is much larger than any heretofore obtained from that section of the Southwest, and includes many interesting objects, illustrative of their out-door ceremonies, such as sacred spring, cave and shrine worship, also a large number of water-color sketches illustrating many

of their sacred dances. About three hundred fetiches were also obtained, representing nearly every animal and object held in high esteem by the Zuñis, *e. g.*, hunting charms, war and prey gods. A series of photographic views was also made of the sacred springs, wells, monuments, picture-writings, and shrines of the Zuñis, scattered over an area of about 75 miles in all directions from Zuñi, and a collection of representative specimens of their gods, idols, plume-sticks, and other religious objects was secured. These collections have already been received at the National Museum, where they will be arranged, classified, and described. Full notes, detailing the observations made in the field, as well as a descriptive catalogue of the collections made, will appear in a forthcoming report of the Bureau of Ethnology.

Mr. Victor Mindeleff was, at the beginning of the year, in charge of a party collecting pottery at Acoma, N. Mex. He secured and shipped about 1,000 specimens before returning to Washington, in the month of February. He also made a close architectural survey of the village, securing such plans and data as were necessary for the preparation of a detailed model. In August he returned to New Mexico, visiting the Chaco group of ruined pueblos in order to secure detailed plans, photographs, and other materials for the preparation of models, spending about two months in that work. In October he made a survey and measurements of the large Etowah mound near Cartersville, Ga., preliminary to constructing a model to be added to the mound series of the Bureau.

General Field Studies.—In the beginning of 1884 Mr. Frank H. Cushing undertook systematic explorations of the sacrificial grottoes and votive shrines of the Zuñis in the main and tributary valleys of their pueblos. In and upon the mesa of Tâai ycel lon ne or Thunder Mountain alone, he found eight of these depositories, three of which proved to be entirely prehistoric, the others partially so. On the head-lands, both north and south of Zuñi, he traced eleven additional shrines, and near both Pescado and Nutria found others, all rich in ancient remains. More important than any of these, however, were three caverns, or rock-shelters, situated in two cañons, one some 9 miles east of Zuñi, the other southeast and nearer the pueblo by 3 miles. Two of these caves were of a remote date as receptacles, one containing a burial cairn, the other an extensive accumulation of well-preserved idols of war and rain-gods, symbolic altar-tablets, sacred cigarettes, long and short prayer-wands, and numerous samples of textile, cordage, and plume work. The latter deposit was the more important in that, beside being still used and held sacred by the Zuñis—hence clearly referable to their ancestry—its contents evidently connected it with the crater and cave-shrines discovered by Mr. Cushing on the Upper Colorado Chiquito in 1881, and described in the report of his explorations for that year. As, however, he was forced to visit these places either in company with Indian companions or by stealth, he had to leave his rich finds undisturbed.

Pursuing his explorations southward, he discovered, between 20 and 30 miles from the central Zuñi valley, not only two caves, containing sacrificial remains, but also a number of cemeteries of undoubted ancient Pueblo Indian origin. These burial places yielded perfect crania and well-preserved vessels of earthenware, and in all respects save in extent were identical with those of Arizona examined and reported on by him during the spring of 1883.

He explains the non-discovery heretofore of Pueblo burial places by the fact that the primitive house-building Indians, although they at first practiced burial by interment, must have carried the remains of their dead (judging by the cemeteries under discussion) to great distances from their permanent homes; that afterward, when the present methods of terraced communal architecture (induced by defensive confederations and productive of conditions and populations rendering such burials impracticable) began to prevail, "water sepulture" came into vogue. This was, according to Zuñi tradition, performed by cremating the bodies, then carrying the remains to sacred springs or lagunes into which they were cast. Mr. Cushing returned to Washington in the month of May.

Mr. H. W. Henshaw visited California for the purpose of pursuing linguistic studies in the Santa Barbara family of languages. The rapidity with which the tribes of the Southern Californian coast died away when brought under the sway of the Spanish missions is well known, and he found only about fifty survivors of the once populous tribes of this family. Several dialects have become extinct. He visited Monterey, San Luis Obispo, Santa Barbara, and Ventura Counties, and obtained vocabularies of eight distinct dialects of this family, all that now survive. Los Angeles and San Diego Counties were visited with the view to determine the limits of the Shoshonian and Yuman families, and several vocabularies of each family were collected.

Mr. Albert S. Gatschet traveled early in August to Fort Sill, Ind. T., to study the languages of the Comanche, Apache, and Kaiowa Indians residing there. He then proceeded to Fort Worth, Tex., where he obtained a large vocabulary, with texts and sentences, of the Lipan language, and later to Fort Griffin to obtain similar information from the Tonkaway Indians. While at the latter place, he obtained from old Tonkaway Indians a vocabulary of the Karankawa Indians, a tribe said to have lived over fifty years ago in the vicinity of Matamoros. This appears to be new to linguistic science. A short list of words was also obtained of the Hanáme language, which also appears to belong to an extinct tribe.

Returning to Fort Sill, Mr. Gatschet obtained further linguistic information on the Kaiowa language; and after going to Anadarko, Ind. T., extensive vocabularies were gained from Kaiowa, Caddo, Yatassi, and Anadarko Indians, the last two being dialects of the Caddo language. At Austin, Tex., historic and linguistic information relating to

Indians of Texas and California was found in the State library. At the close of the year he was still at Saint Charles, La., studying and collecting linguistic material of the language of the Atakapa Indians.

Rev. J. Owen Dorsey visited the Siletz Agency, Oregon, in August, 1884, to gain linguistic and other information respecting the tribes in that region. When he returned in November, 1884, he brought back the following vocabularies: *Athabascan family:* Applegate Creek, Galice Creek, Chasta Costa, Mikono tunne, Tutu tunne (and Joshua), Yukwitce, Sixes, Naltunne tunne, Chetcoe, Smith River, Cal., and Upper Coquille. *Yakonan family:* Siuslaw, Umpqua, Alsea, and Yaquina. *Unclassified vocabularies:* Takelma or Upper Rogue River, Molluk or Lower Coquille, Klikitat, Sasti. Total, nineteen vocabularies, ranging from fifty to three thousand entries, exclusive of phrase and grammatical notes. He also obtained materials for an account of the social organization of some of these Indians in villages, which appear to have been clans, illustrated by rough maps, showing the localities of such villages. Mr. Dorsey also gained the corresponding Indian names from several tribes of about sixty vegetal products, specimens of which were brought to Washington for identification.

Dr. W. J. Hoffman proceeded early in August to Victoria, B. C., where a large collection of sketches of Haida totem-posts and carvings were obtained, in connection with the myths which they illustrated. At this locality attention was paid to the burial places and osteologic remains of the nearly extinct Songhish Indians. Meeting with a large party of Haida Indians at Port Townsend, Wash., he examined a large number of individuals of both sexes to study and sketch the tattooed designs with which they were profusely decorated. Definitions and explanations of these designs were obtained, together with the details of the process employed in tattooing by the Haidas, as well as the other tribes living on Puget Sound, Cape Flattery, etc. A collection of Eskimoan pictographs and ivory carvings were also copied at the museum of the Alaska Commercial Company, San Francisco, Cal.

At Santa Barbara, Cal., Dr. Hoffman discovered several interesting painted records, and examined a number which have not yet been recorded. These records are usually found in mountainous country, and near passes. Similar records were also visited 30 miles northeast of Los Angeles, Cal., and at Tule Indian Agency, in the deep valleys on the western slope of the Sierra Nevada, near Porterville. By far the greatest amount of pictographic material was collected in Owen's Valley, Cal., where a number of series of petroglyphs are scattered over an arid, sandy desert, the extremes being about 20 miles apart. Although many of the characters appear to resemble some of the figures drawn by the Moki of Arizona, the greater number have not as yet been noted from any other portions of the United States.

During the months of May and June Mr. W. H. Holmes visited Mexico, and secured much valuable information upon the relative ages

of the ceramic products of that country. His collection, consisting of several hundred pieces of ancient ware, has been presented to the National Museum.

Dr. H. C. Yarrow spent the months of August and September, 1884, in the Territory of Utah to prosecute ethnologic inquiries. Several mounds were carefully examined at Provo, 50 miles south of Salt Lake City. These did not afford any specimens, but showed the manner in which the former Indian inhabitants of the Great Salt Lake Valley constructed their adobe dwellings. From Provo he proceeded west to a place known as the "Old Government Ranch," where an Indian burial cave was discovered, which for some years had been used by the Goshute Indians, from which the Indian remains were removed. From here he crossed the southern limb of the American desert and reached the settlement of Willow Spring, at which point a number of burial places were discovered, giving results of interest. Thence he went to Deep Creek, the present home of the band of Goshute Indians, numbering about 150 souls; learned from them the meaning of many of their ceremonies and burial rites, and obtained a collection of articles of native manufacture. A similar collection with information thereupon was obtained from the band of Pahvants at Fillmore, Utah.

Mr. Jeremiah Curtin prosecuted studies in Indian philosophy and folk lore among the Senecas in Missouri, during the month of February, and later from the Shawnee and other Algonkian tribes in Missouri and Indian Territory. In June he visited the Seminole Indians in that Territory with the same object in view, and in October proceeded to Redding, Cal., where he continued the collection of myths among the Nozi Indians.

2. *Office Work.*

The Director, Maj. J. W. Powell, has continued the work, first, of classifying on a linguistic basis all the tribes, remaining and extinct, of North America; second, of establishing their synonomy or the reference of their many and confusing titles as given in literature and common usage to a correct and systematic standard of nomenclature; and third, of the ascertainment and display on a series of charts of the habitat of all tribes when first met by Europeans or subsequent periods. Much progress has been made in this undertaking, recognized as essential to the proper study of Indian anthropology.

Col. Garrick Mallery was engaged during the year in the continued study of sign language. A number of important collections of gesture signs were procured from parts of the United States not before thoroughly explored in this respect. Collections of great value were also obtained from Japan, Asiatic Turkey, and from several of the Polynesian groups. The increased collection of material, with its collation, indicates that while one system of gesture-speech has long existed among the North American Indians, it is not to be regarded as one

ormal or absolute language; several groups with their centers of origin being indicated. Five of these groups appear, from present information, to be well defined as follows: First, the Arikara, Dakota, Mandan, Gros Ventre or Hidatsa, Blackfeet, Crows, and other tribes in Montana and Idaho. Second, Arapaho, Cheyenne, Pani, Kaiowa, Caddo, Wichita, Apache of Indian Territory, and other tribes in the Southwest as far as New Mexico, and possibly portions of Arizona. Third, Pima, Yuma, Papago, Maricopa, Hualpai (Yuman), and the tribes of Southern California. Fourth, Shoshoni, Banak, Pai Uta of Pyramid Lake, and the tribes of Northern Idaho and Lower British Columbia, Eastern Washington, and Oregon. Fifth, Alaska, embracing the Southern Innuit, Kenai (Athabaskan), and the Iakutat and Tshilkaat tribes of the Thlinkit or Koloshan stock. The gestures of Alaskan tribes present marked difference to any of the southern tribes.

The gestures still used by the Indians of British Columbia and the northern part of Vancouver's Island, also by the Iroquois of Canada, are not at present classed in any group.

In the comparison made between the gesture signs of the several bodies of speaking men and between those groups and the signs of deaf-mutes, it appears that variation in form is frequent, while identity of system is preserved. Not only do many of the particular signs of deaf-mutes in America differ from those with the same signification in some countries of Europe, but a similar disagreement is observed among the several institutions for deaf-mute instruction in the United States. When the diverse signs are purely ideographic, they are, however, intelligible to all persons familiar with the principles of sign expression; but when, as frequently occurs, they are conventional, they cannot be understood without the aid of the context, or without knowledge of the special convention. The similar instances of diversity among the Indian signs are so numerous that a vocabulary confined to the presentation of a single sign for each of the several objects or ideas to be expressed would be insufficient and misleading. Variants must be supplied with designation of the several groups using them. There being no single absolute language, each of the prevalent forms of expression has an equal right to consideration, without which a vocabulary must either be limited to a single so-called dialect, or become the glossary of a jargon. For this reason the collation of the gesture-signs of the North American Indians for scientific examination requires minute care, and when they are critically compared with the signs of other speaking men, ancient and modern, and with those of deaf-mutes, the work is much protracted.

Colonel Mallery has also continued the study of pictographs, and has prepared for the press a preliminary paper on that subject intended to guide research and procure collaboration. The collection of pictographs has been largely enriched during the year, especially by the discovery of six forms of Dakota Winter Counts, which have been col-

lated with the one form published in the year 1877 by Colonel Mallery, under the title of "Calendar of the Dakota Nation." The wide circulation of his paper on this subject was the means of obtaining the additional copies, valuable as a verification and for correction, and also extending over a longer number of years than the one first published. The collected Winter Counts now furnish a large amount of ethnologic information wholly apart from the interest attached to them as calendars. In the whole of these studies Colonel Mallery has been assisted by Dr. W. J. Hoffman.

Mr. Frank H. Cushing, on his return to Washington in the spring of 1884, renewed his work of the classification of his material obtained in the field and its preparation for publication. He completed an essay on the culture-growth of the Zuñis, as illustrated by studies of the Pueblo pottery, and has prepared a paper on the ancient province of Cibola, and the Seven Cities, with explanation of the architectural types in the Southwest, and the social institutions connected with the several periods of that architecture. He has also arranged his copious notes on the myths and folk-lore of the Zuñis.

The preparation of the Bibliography of North American Linguistics by Mr. James C. Pilling was continued during the year. There were received from the printer during the year proof-sheets of pages 839–1135, and these were distributed to various gentlemen throughout this country and others for examination and criticism. Among them were Señor Joaquin Garcia Icazbalceta, of the city of Mexico; Mr. Wilberforce Eames, of New York City, and Drs. J. G. Shea, of Elizabeth, N. J., D. G. Brinton, of Media, Pa., and J. Hammond Trumbull, of Hartford, Conn., from all of whom valuable information was obtained. During the latter part of October and the early part of November Mr. Pilling made a brief trip to New England, visiting several libraries in Boston and Providence for the purpose of clearing up a number of doubtful bibliographic points.

Mr. H. W. Henshaw was engaged during the earlier part of the year in assisting the Director in the work of the classification of the languages of the North American Indians. The large number of vocabularies of Indian languages which have been collected from time to time, and the recent increased activity in the direction of linguistic studies, imperatively require that a classification shall be made upon a more comprehensive and satisfactory basis than has hitherto been done. The confusion of nomenclature observable in previous classifications, and the perplexities to the linguistic student resulting therefrom, are universally recognized. Since Gallatin's classification of 1836 the grouping of linguistic families has undergone great changes at the hands of successive authors in accordance with conflicting views held by them, and the families have been named and renamed with little or no reference to the names previously given. It is believed that in linguistic as in zoologic classification priority of name is the

only safe rule to follow, and careful examination of all the literature pertaining to Indian linguistic classification with a view to a determination of the name first employed for a family, together with carefully-compared tables of synonymy, was therefore indispensable. In the work indicated, Mr. Henshaw prepared a system of tables on the principle explained, and in connection with them a brief account of the literature bearing on the subject.

Prof. O. T. Mason finished compiling the census of Indian education from the time of the foundation of the Government, and collected additional material for a grammar and dictionary of the Chahta language.

Mr. W. H. Holmes has been engaged during the year in carrying forward his studies of American ceramics, and has made much progress in the classification and arrangement of the collection of pottery in the National Museum. He has also prepared a paper upon the fine collection of mound pottery in the museum of the Academy of Sciences at Davenport, Iowa, which will appear in the Fourth Annual Report of the Bureau. For the same volume, he has completed a paper upon the origin and development of form and ornament in the ceramic art, with copious illustrations. Mr. Holmes remains in charge of the department of illustrations in the Bureau of Ethnology, as well as in the Geological Survey, and has made good progress in elevating the standard of work. He has also had charge of the preparation of the exhibits of the Bureau of Ethnology and of the Geologic Survey for the exposition at New Orleans.

Mr. C. C. Royce continued his examinations into the primal title of the different Indian tribes to lands within the limits of the United States, and the methods employed by the United States authorities in securing from such tribes a relinquishment of their title to such lands. Special attention was given to compiling the data in connection with the extinguishment of the Indian title to lands within the present limits of Oregon, Washington Territory, California, Arizona, New Mexico, Nevada, Utah, Idaho, Wyoming, Montana, Dakota, Texas, Minnesota, Kansas, and Nebraska. The investigations before commenced in other States have also been completed, and it is expected that the entire work will be ready for publication within the year 1885.

Rev. J. Owen Dorsey, when not in the field, made many entries for an Osage-English dictionary, and for a Kansas-English dictionary, prepared Osage and Kansas native texts with free and interlinear translations, and entries for the Egiha-English dictionary. He also prepared articles on Kansas War Customs, and Migrations of certain Siouan tribes, each one illustrated by charts. A manuscript Musquito dictionary was examined and criticised. After December 1, 1884, he collated the following vocabularies gained in Oregon, viz: Takelma, Sasti, Applegate Creek, Chasta Costa, Galice Creek, Mulluk, Siuslaw, Umpqua, Yaquina, Klikitat, and Smith River, California. He also prepared a list of the villages obtained from the tribes at the Siletz Agency, Oregon.

Mr. Albert S. Gatschet, before proceeding to the field, as above mentioned, was occupied in reading proof of his Klamath dictionary; the second or English-Klamath part, and in correcting and largely rewriting the manuscript of his Klamath grammar from the copious notes made during the printing of the text and the dictionary.

Mrs. Erminnie A. Smith continued her special study on the different Iroquoian dialects. The Mohawk words previously translated from the dictionary of Marcoux were all recopied and their literal meaning given, as were also over 6,000 words in the Tuscarora dialect. She also prepared several studies upon pronouns and other parts of speech, for use in the introduction to her Iroquoian dictionary, which is in course of preparation.

Dr. H. C. Yarrow, acting assistant surgeon, U. S. A., during the part of the year in which he was not, as elsewhere reported, engaged in field work, continued his investigations into the mortuary customs of the North American Indians; maintaining the large correspondence relating thereto, and arranging, with a view to publication, the large amount of material collected by him subsequent to his preliminary paper on the above-mentioned subject.

Mr. Victor Mindeleff was occupied, when not in the field, in the preparation of a map of Cañon de Chelley and its branches, from the data obtained in the field during the last season, for the purpose of showing the relation of the large number of cliff ruins (the plans of which had been obtained) to the topography of the cañons. He also continued the work of modeling the Moki villages, which had been interrupted by his field trip, in a series of models illustrating ancient pueblos and cliff ruins, prepared by him for the New Orleans Exposition.

UNITED STATES GEOLOGICAL SURVEY.

Although separate in organization and management, the Smithsonian Institution and the Geological Survey have enjoyed at all times such close personal and official relations that it has been customary to include a summary of the yearly operations of the Survey in the annual report of the Institution. In pursuance of this custom such a summary, furnished by Maj. J. W. Powell, the Director of the Survey, is appended hereto.

The increased appropriation for the Geological Survey for the fiscal year 1883–'84 made improved organization and greater expansion possible. To the former nothing contributed more than the obtaining of suitable office accommodations—a want long felt, and finally rendered imperative by the enlargement of the Survey. Formerly the Director's office and executive force were in one place, the quarters of the geologists and geographers in another, while many divisions that should have been in Washington under the immediate supervision of the Director were scattered in remote cities. This unsatisfactory condition

of affairs was ended by securing a lease of the Hooe iron building, a large fire-proof structure on F street, to which the Survey force, with the exception of the chemists and paleontologists, was removed in October. As this building did not offer laboratory facilities, the chemists were permitted, through the kindness of the Director of the National Museum, to occupy the northeast pavilion left vacant by the removal of the Director's office, while the paleontologists retained their old rooms in the Museum, it being impracticable to separate them from their collections, to which constant reference must be made, and which by law are installed in the Museum. As these gentlemen also serve in the capacity of honorary curators in the Museum, this arrangement seems especially appropriate.

Before taking up the specific items of survey work, it is most gratifying to refer to the friendly relation subsisting between the various State surveys and the Geological Survey, and especially to the active co-operation of many of the former with the latter in its efforts to include the whole country in its geologic investigations.

The detailed statements which follow under the heads of Geography, Geology, Paleontology, Chemistry, Statistics, Publications, and Collections, indicate satisfactory progress made during the year.

For purposes of general reference it was found desirable to retain the Divisions of the North Atlantic, South Atlantic, North Mississippi, South Mississippi, Rocky Mountains, and Pacific. The Division of the Great Basin was abandoned, it being necessary to withdraw Mr. G. K. Gilbert therefrom and place him in charge of the Division of the South Atlantic. For convenience of topographic reference these large areas are again subdivided into districts such as "New England," "Appalachian," &c.

GEOGRAPHY.

In the geographic work of the Survey it is constantly borne in mind that it is only possible to carry out the intent and purpose of the law requiring the construction of a geologic map of the United States, by first preparing an accurate topographic map which can be placed in the hands of the field geologists. In pursuance of this policy, as soon as the material of the previous season had been reduced to permanent form, active preparations were made for field work with an increased and more effective force. As soon after July 1, as practicable, 27 topographic parties were organized and took the field under the guidance of their respective chiefs.

Division of the North Atlantic

New England District.—Encouraged by the topographic work begun in Massachusetts during the previous season, the legislature of that commonwealth appropriated the sum of $40,000 for the further prosecution of the work in connection with the Geological Survey. In view of

this fact the number of field parties was increased to four. This necessitated greater supervision, and in order that the inauguration of the survey upon this more comprehensive plan might be made under the most auspicious conditions, its general management was undertaken by the Chief Geographer of the Survey, Mr. Henry Gannett. The season's work included the counties of Hampshire, Bristol, Norfolk, and Plymouth, and embraces an area of 658 square miles.

New Jersey District.—Under arrangements very similar to those entered into with Massachusetts a survey of New Jersey was commenced, and one topographic party, aided by two subordinate parties, was assigned to the work. Professor Cook, State geologist, kindly undertook the direction of this force. With the exception of a small area in Sussex County all the northern counties had been completed under State direction. During the field season Sussex was finished and considerable progress made in Monmouth and Ocean Counties. The area surveyed up to December 31 was 1,082 square miles.

Appalachian District.—During the previous season the chief geographer of the Survey had given much of his time to the supervision of the work of his district. His withdrawal to New England made it necessary to secure the services of some other competent geographer, and Mr. Gilbert Thompson was relieved from the direction of the California district, and placed in charge of the Appalachian. Before the 15th of July the large force assigned to this district was organized into seven principal parties and field-work commenced. These parties operated in Eastern Maryland, Northeastern and Southwestern West Virginia, Western Virginia, Eastern Kentucky, Eastern Tennessee, Eastern North Carolina, and in Northern Alabama and Georgia. The total area covered in these States was 17,466 square miles. This work required the construction of between 8,000 and 9,000 square miles of triangulation and the connection of portions of it with the triangulation of the Coast and Geodetic Survey.

Divisions of the South Mississippi and the Rocky Mountains.

Heretofore topography was undertaken only in the latter division, but the increased appropriation permitted its extension into the former also. As Prof. A. H. Thompson had previously been in charge of the parties in this region the additional territory was also placed under his management.

Missouri and Kansas.—One topographic party was sent into each of these States, and in addition to this an astronomic party took the field for the purpose of making observations from which to determine the positions to be used by the topographers as a basis for their work.

In anticipation of the extension of the survey into these States, much valuable topographic material was compiled from all available sources before the parties left for the West; and, as in many cases it was only

necessary to add the elements of relief and culture to the plats, rapid progress was made. It is estimated that not less than 15,000 square miles were covered by the two parties during the season.

Texas.—The work in Texas was successfully inaugurated about August 1, the chiefs of three parties and their assistants reporting at that time at Austin, Tex. As no work had heretofore been done in this district, the establishment of a base-line and the connection of the triangulation with that of the Coast and Geodetic Survey was necessary. As it is a region of small details, and this, together with the presence of much timber and embarrassing atmospheric conditions, made the work tedious. Nevertheless, the party succeeded in covering an area of 4,000 square miles.

Arizona and Nevada.—Work having been carried on in this region during previous years, there was but little delay in putting into the field the three parties—one triangulation and two topographic—assigned to this district. As this is the region peculiarly favorable to topographic work, the unusual area of 36,900 square miles was surveyed.

Yellowstone National Park.—The topographic work in the Park remained in the charge of Mr. John H. Renshawe, who, with three parties, carried forward the survey from the points where it was discontinued at the close of the last season. One thousand square miles were added to the area already surveyed, leaving one-half of the Park yet to be completed. This, however, is a rugged, mountainous district, unfavorable to rapid work, and it is expected that future progress will be slow. Recent attempted legislation concerning the Park boundaries and the relation thereto of settlers' vested rights add interest to this survey.

Division of the Great Basin.

As previously stated, geologic work in this division was discontinued. A certain amount of topographic work was done, however, by reason of the extension of the survey across the western boundary of Arizona into the southern part of Nevada—the object of this extension being to unite large areas already surveyed.

Division of the Pacific.

Northern California District.—Two parties were sent to California and placed under the direction of Mr. Mark B. Kerr, who in previous years had been in charge of parties under Mr. Gilbert Thompson's direction. In addition to covering 3,700 square miles, detailed surveys of 375 square miles within this same area were also made.

At the closing of this report all of the field parties were not in, but sufficient data are at hand upon which to base the close estimate that an area of nearly 80,000 square miles was surveyed during the year. The reduction to permanent shape of this material will be taken up by the different divisions immediately upon their return, and will be completed before the close of the fiscal year.

GEOLOGY.

For some time it had been the wish of the Director to extend geologic investigation into certain fields which, owing to limited funds, it had not been possible to study. It is very gratifying to note that at the beginning of the fiscal year much was accomplished in this direction by the addition of several eminent geologists to the Survey staff, as well as by securing the active co-operation of others whose duties would not admit of their assuming additional obligations. The former will be mentioned specifically in referring to their respective fields of work; the latter include such well-known scientists as Professor Hall, of the Geological Survey of New York; Professor Newberry, of the School of Mines, Columbia College, New York; Professor Safford, of the Geological Survey of Tennessee; and Professor Cook, of the New Jersey State Survey.

North Atlantic Division.

New England District.—The discontinuance of the transcontinental survey by the Northern Pacific Railroad left Prof. Raphael Pumpelly free to engage in other lines of work, and his services were secured for the direction of the investigations to be undertaken primarily in the Archean formations of the Atlantic slope. The general plan of procedure will be to take up the investigations in New England and extend them southward, at the same time carefully studying the many other problems connected with this region. In pursuance of this plan, preliminary reconnaissances were made in New England towards the close of the current year.

Prof. N. S. Shaler, of Harvard University, who has given considerable attention to the geology of New England, will be associated with Professor Pumpelly in this task. Pending the final decision as to the course to be pursued, Professor Shaler found time, with the aid of volunteer assistants, to study the geologic history of Cape Cod; to continue his examination of the Narragansett coal fields; to examine critically 100 miles of the main shore line, obtaining valuable collections of fossils therefrom; to make observations as to the evidences of recent shore-line movements; to study the drift-sheet of this region; and to bestow some attention on the phenomena connected with swamps.

Much information concerning the geology of New Jersey had already been acquired by Prof. George H. Cook, the State geologist, and the publication of the material provided for by the State. Under arrangements with Professor Cook the paleontology of New Jersey is to be published hereafter by the United States Geological Survey. A reference to the paragraph on "Publications" will show that the carrying out of this plan has been commenced through the publication by theSurvey of Whitfield's "Brachiopoda and Lamellibranchiata." It has already been noted that Professor Cook, in addition to his geologic duties, undertook the management of the mapping of the unsurveyed portions of the State.

South Atlantic Division.

Appalachian District.—At the time of the withdrawal of Mr. G. K. Gilbert from the District of the Great Basin, he had in course of preparation an elaborate memoir, embodying the results of his investigations concerning the ancient Lake Bonneville and its boundaries, while his immediate assistant, Mr. Russell, was engaged in the preparation of a like report upon Lake Lahontan and a paper upon the Mono Basin. For these many illustrations had been made, and others that were being drawn required constant supervision. Attention to this material occupied much of Mr. Gilbert's time, but early in the field season he found opportunity to make a preliminary study of the structure of the Appalachian system. For this purpose he proceeded, via Lynchburg, Va., to Asheville, N. C. From this point a series of excursions were made to Mount Mitchell, Roan Mountain, and to the valleys of several of the tributaries of the French Broad. The journey was then continued southward across Tennessee, and as far into Georgia as Ellijay. While the object of this trip was the general study of the history of the Appalachian system, especial attention was given to that phase of it which is represented by the ancient base-levels in the mountain valleys. Later in the season Mr. Gilbert made similar observations upon the terraces of the valleys of the Passumpsic, Connecticut, and Mohawk, for comparative purposes. In the mean time, he sent the assistant geologists, who had previously acted in this region under the Director's immediate instructions, but who were now placed under his direction, to make a detailed study of the geologic phenomena of the Kanawha Valley, West Virginia, of the country in the vicinity of the White Sulphur Springs, and of a portion of the great valley of eastern Tennessee. At the close of the calendar year satisfactory progress was reported in these several fields of work.

Division of the North Mississippi.

Glacial District.—A summary of what was accomplished by Prof. T. C. Chamberlin and his assistants shows six months' of office duty in connection with the previous season's material and six months of outdoor work in extending the research into new fields. The first half of the year was given to the preparation of a paper on "Requisite and Qualifying Conditions of Artesian Wells," for the Director's Fifth Annual Report, a report upon gravel deposits, and the collation of the observations made upon glacial striation. The field work of the last half of the year included (1) an expansion of the previous studies of the driftless area of Wisconsin, Illinois, Iowa, and Minnesota; (2) the continuation of previous work in Dakota, more particularly the detailed study of the moraines of the southern part, and a critical examination of their relation to other deposits; (3) the tracing of the outer limit of the northern drift from the point to which it had been previously traced in Indiana westward to the Mississippi River; (4) the study of the terraces ot

the Upper Ohio and the hypothetical effects of ice blockage; (5) the more complete mapping of the osars of Maine, together with a critical study of their structure, character, and relation; (6) a comparative study of glaciated and unglaciated Archæan knobs which occupy an isolated position in the Silurian district of Central Wisconsin, and (7) a study of the northern border of the Missouri Valley loess and its relation to other members of the Quaternary series, as well as to altitude, topographic features, and drainage systems.

The tracing of the boundary of the drift and loess was undertaken by Professor Chamberlin in person. The limit of the drift will be indicated in a manner by the statement that his examination carried him across Northeastern Illinois, Southern Iowa, Southeastern and Central Nebraska, as far west as Denver, Colo., thence into the Valley of the Arkansas southward across Indian Territory to Northern Texas, and thence eastward across the northern part of Louisiana to the flood-plains of the Mississippi, and from this point northward through Western Tennessee, Kentucky, and Eastern Missouri. The results of the investigations of Professor Chamberlin and his assistants will appear from time to time in the form of monographs and bulletins.

Lake Superior District.—Office work in connection with the investigations of this division occupied the time of Prof. R. D. Irving and his assistants until the weather permitted field exploration, which was at once taken up and continued until nearly the close of the calendar year. Professor Irving's line of research lies mainly in the Cambrian and Archæan formations of the Lake Superior region. The assistants under his direction were employed in the following fields: One was sent to study the gneisses and granites of the Minnesota Valley, the results to be used, in connection with data obtained last season, in preparing a bulletin on the gneisses and granites of Central Minnesota; another was sent to the Gogebic Lake country of the northern peninsula of Michigan for the purpose of connecting the Huronian of the Penokee region of Wisconsin with that of the Marquette and Menominee regions of Michigan; a third continued the studies previously made in the region of the national boundary line in the vicinity of Knife Lake, Minnesota—the object of the investigations being to determine the relation between the flat lying Animikie and the more northerly folded schists; a fourth assistant was assigned a large area stretching from Vermilion Lake, Minnesota, northeastwardly to its juncture with the region in which the party just referred to operated, while for himself Professor Irving reserved the necessary supervision of his subordinate parties; a special study of portions of the Marquette region hitherto unexplored, and a further examination of the exposures along the national boundary-line, in the neighborhood of the Lake of the Woods. The various parties had about completed the tasks assigned them and returned to the Madison office for the purpose of elaborating the results of this successful field season, when they had the misfortune to lose

much of the labor of this and previous years by the fire which occurred in the Science building of the University of Wisconsin, on the night of December 1. This conflagration destroyed most of their collections, instruments, and field equipage; seriously damaged their field-notes, manuscript text and accompanying illustrations, and a number of excellent field-maps upon which the geology thus far determined had been laid down, and also ruined a quantity of carefully-prepared micro-sections. At the time of the fire, Professor Irving and his assistants had well under way papers upon the following subjects: (1) Observations on the contact-line between the western sandstones and the copper-bearing series on Keweenaw Point, to be issued jointly by Professors Irving and Chamberlin; (2) Notes on the preliminary geologic map of the region bounded by Lake Superior, the national boundary-line, and the Saint Louis and Vermilion Rivers; (3) The geology of the region between Gunflint and Knife Lakes; (4) The geology of the region west of Knife Lake and lying between the national boundary-line, Vermilion River, and the Mesabi Range; (5) The Penokee-Gogebic iron-bearing series, and (6) The cherts, jaspers, and iron ores of the Huronian of the Northwest. Professor Irving and his assistants at once set about repairing the damage done by the fire, and while it will be possible to reproduce much of this material, delay in its publication must necessarily follow.

Rocky Mountain Division.

Montana District.—Prof. F. V. Hayden and assistants continued investigations in Western Montana. The special field of work selected was the eastern and northern sides of the Gallatin Valley, the west side of the Bridger's Range, and the country in the vicinity of the Forks of the Missouri River. The object of the reconnaissance was the completion of the section of the Silurian and Cambrian formations which are so well exposed in this region. In traveling to and from the field of work a careful examination was made of the springs of Western and Southeastern Montana, Idaho, and Utah, for the purpose of obtaining data to be used in connection with the list of mineral springs of the United States, which is being prepared by Dr. A. C. Peale.

The publication by the Geological Survey of Canada of the results of investigations in British Columbia enabled Dr. Hayden to ascertain with more definiteness the relation of the geology of the region being studied by him to that of the country extending to the northward into British Columbia.

Yellowstone Park District.—By the last of June Mr. Arnold Hague and assistants completed office-work in connection with the material collected during the previous season, and were ready to take the field. A reference to the season's work in detail shows that it was only by adopting a comprehensive plan of procedure and dividing the force up into small parties that it was possible to make the most of the short field-season in the Park. A careful compilation of such observations as had

been made from time to time upon the geysers enabled Mr. Hague to institute a more systematic study of the changes and modifications. Skilled observers were kept in the principal geyser basins, and as far as possible the more remote and less active thermal springs were visited and the phenomena connected therewith carefully noted. Two parties, one of which was under Mr. Hague's immediate direction, made a preliminary study of the East Gallatin Range, which forms the northwest boundary of the Park Plateau, and extends from Electric Peak southward to Mount Holmes. Geologically considered, this range is a most interesting one; every period from the Silurian to the Colorado Cretaceous being represented therein. A special study was made of the Obsidian cliffs, and later in the season the volcanic rocks of the west shore of the Yellowstone Lake, together with its Quaternary geology, glacial phenomena, and ancient terrace-lines, were carefully worked up.

In connection with the geologic investigations, Mr. Hague also made a preliminary examination of the region named in the bill before the Forty-eighth Congress for addition to the Park reservation.

The several parties were compelled by reason of snow-storms to leave the Park by the middle of October. Upon returning east the force of this division were removed from their quarters in the American Museum of Natural History, in New York, to the Survey building, in Washington.

Colorado District.—During the winter Mr. S. F. Emmons and assistants made further study of the material collected from the Silver Cliff mining district, and, as soon as the field season opened, topographic and geologic work was taken up in the Gunnison district. In connection therewith, and in order that a better understanding might be obtained of the Colorado Paleozoic and Mesozoic, a geologic section was made along the Arkansas River, in the neighborhood of Salida. The result of the season's work will enable the geologists to lay down the geology of the Gunnison district upon the map of the region which was prepared at the same time. As soon as the weather made further research in these fields impossible, attention was turned to the geologic phenomena of the Denver Basin, especial attention being given to the source of the water-supply of its artesian wells. The investigations in this region, dealing as they do with the mineral-bearing formations, require a large amount of laboratory and microscopic work, in the course of which some very interesting discoveries were made as to the occurrence of minerals both in combinations and in localities in which they were not supposed to exist. The results of these investigations of the minerals of Colorado will appear at a future day in the form of a Bulletin.

District of the Pacific.—At the close of the previous annual statement, the investigations of Mr. George F. Becker and his assistants in the quicksilver deposits of Sulphur Bank and New Idria, California, were sufficiently near completion to permit the entering upon new fields. It was decided, therefore, to take up the study of the Knoxville

district, and the mines in the vicinity of Steamboat Springs, to be followed later by an examination of the cinnabar deposits of Guadaloupe and New Almaden. The climate of California makes field-work possible at all times of the year, and Mr. Becker kept in mind the desirability of not only making a careful study of the surface geology of the area immediately under investigation, but also of utilizing all trips to and from the field of work for the purpose of obtaining a thorough knowledge of the general geology of California, and its relation to the quicksilver deposits. In addition to this, special trips were made whenever necessary to localities thought to be instructive or furnishing any clue to the solution of the geologic problems of this region. With such ends in view, the construction of a geologic section through the Coast Range was undertaken. In view of the extensive studies made by Mr. Becker and his assistants, and as a check upon their conclusions concerning the age of the quicksilver-bearing rocks of the Pacific coast, it seemed wise, before proceeding further, to have some competent paleontologist review the results obtained by the State survey and such other material as had been procured recently by Mr. Becker. Dr. C. A. White was assigned this duty, and proceeding to California he first made a study of the Chico, Tejon, and Miocene groups, and then, in company with Mr. Becker, visited the several mining districts under consideration, the Cretaceous and Paleozoic formations of Butte County, and certain other localities on the McCloud River, and in Shasta and Mariposa Counties. They then proceeded as far north as Eugene City, Oreg., for the purpose of examining a large and very instructive collection of fossils in that city.

Much microscopic and chemic work has been accomplished in the laboratory of this division, in connection with the cinnabar investigations.

Assistant Geologist Curtis completed his report on the Eureka mining district, and early in the year proceeded to Washington to superintend its publication. When not engaged in this task, his time was devoted to experimenting for the purpose of devising improved methods for determining minute quantities of precious metals in ores.

Volcanic Rocks.—Having nearly completed the manuscript of his memoir on the Hawaiian volcanoes, Capt. C. E. Dutton, U. S. A., in pursuance of his investigations relative to volcanic phenomena, proceeded to Fort Wingate, N. Mex., in July, for the purpose of making a thorough examination of Mount Taylor and its vicinity, a region which in past time was one of great volcanic activity. In the mean time the investigations previously conducted in the Cascade Range were not forgotten, and Assistant Geologist Diller spent the field season in the neighborhood of Mount Shasta with most gratifying results. An area embracing 400 square miles was explored; the successive lava-flows which had taken place from the main crater, as well as from the many vents upon the slopes of this extinct volcano, were traced; the limits of

the glaciers and the accompanying phenomena were determined with as much accuracy as possible, and collections were made which enabled Mr. Diller to indicate on the map, prepared at the same time by a topographic party, the distribution of the material forming the successive flows. A large number of photographic views were also taken, which, with field-notes and sketches, will be invaluable in setting forth the geology and topography of this interesting region.

Upon Mr. Diller's return from the field, a well-equipped petrographic laboratory was fitted up under his direction in the Survey building, and an opportunity thus afforded for the microscopic study of the collections of the various divisions. In connection with this laboratory it was found possible to arrange abundant facilities for the preparation of micro-sections. Under Mr. Diller's management most gratifying results have already been obtained from this much-needed acquisition to the Survey's equipment. In the last quarter of the year alone 512 micro-sections were made.

Coal-fields of the Great Sioux Reservation.—On January 3, the honorable the Secretary of the Interior instructed the Director of the Survey to have made a geologic survey of the Great Sioux Reservation, for the purpose of determining the extent and value of such coal-fields as might be found. It was not practicable to undertake this task until the spring. At that time the services of Mr. Bailey Willis were secured, and he, with a party, was sent to Dakota. In addition to the geologic investigations prosecuted by Mr. Willis, he also superintended the preparation of a map of 2,000 square miles, embracing all of the area in which it was expected the so-called coal-fields would be found. Before the close of the year Mr. Willis had completed his report, and it only awaited the preparation of the map to be forwarded to the Secretary of the Interior. While the details of this report cannot be given here, it may be briefly stated that the coal-beds were found to be confined to restricted areas, and to be of but little if any value for commercial or domestic purposes.

Geologic map of the United States.—The geologic map commenced in 1883 was completed and placed in the hands of the engraver. It was found, after collating all available data, that our knowledge is not sufficient to warrant the extension of geologic colors over the entire territory of the United States. Accordingly, California, Oregon, and parts of Montona, Idaho, Nevada, Utah, Arizona, New Mexico, and Texas remain uncolored.

This map will be issued in two editions within a few months. The first edition will be colored in accordance with the scheme previously adopted and published by the Survey. It will form one of the plates of the Fifth Annual Report of the Director, and a brief explanatory statement will accompany it. A second edition, with complete explanatory text, will be issued as a bulletin. In this edition the map will be printed in duplicate, one copy colored in accordance with the published scheme and the other in accordance with a scheme now under consideration. It

is proposed to have this bulletin in readiness for presentation before the Berlin meeting of the Congrès Géologique International during the coming autumn.

The taxonomic scheme is essentially that published in the report for 1883, that is, as follows:

Group.	System.	Symbol.	Color published.	Color proposed.
Cenozoic	Quaternary	Q	Gray	Gray.
	Miocene	M	Chrome yellow	Violet.
	Eocene (including Oligocene).	E	Orange yellow	Indigo.
Mesozoic	Cretaceous	K	Dark green	Blue.
	Jurasso-Triassic	T	Olive green	Green.
Paleozoic	Carboniferous (including Permian).	P	Blue	Yellow.
	Devonian	D	Deep purple	Orange.
	Silurian	S	Light purple	Red.
	Cambrian	C	Grayish purple	Brown.
Azoic	Archæan	A	Brown	Angular figures on white ground.
	Volcanic	V	Red	Round dots on neutral ground.

The sources of the information incorporated in the map are: first, published maps, and second, manuscript maps prepared for the Survey by different official and amateur geologists. As the colors have not been carried beyond the boundaries of the original maps, this geologic map may be regarded as an accurate representation of our present knowledge of the distribution of American rock-groups.

The map, together with the explanatory text, was prepared by Mr. W J McGee.

Geology of the District of Columbia.

The investigation of the superficial deposits, and the littoral and fluviatile terraces of the District of Columbia and contiguous territory, commenced in 1883 by Mr. W J McGee, were continued. A reconnoissance was extended over an area of 1,000 square miles having the District of Columbia as its center. In addition, short journeys to the northward and southward were made for the purpose of correlating the deposits with those already known in other localities; and, with the same object in view, the literature of the Orange Sand and Stratified Drift of the Gulf States, and the glacial "Quaternary," and accociated deposits of the Atlantic States, were studied. In the prosecution of his work Mr. McGee found it necessary to extend his observations into the interior. The Potomac was followed as far as Cumberland, Maryland, and the south branch of that river explored to its source in the elevated tract near the center of the Virginias. Then crossing the main range of the Alleghanies, Mr. McGee descended the Cheat, Monongahela, and Ohio to Wheeling, West Virginia, re-examining the base-level, fluviatile, and lacustral terraces already noted by others on those rivers.

The necessity for increasing the topographic force in New England delayed the construction of the map of this area; but arrangements have been made for its completion, and Mr. McGee will thus be enabled to present in comprehensive form the complicated phenoma of the region which he has under study.

PALEONTOLOGY.

A few changes were made in the distribution of the work of the paleontologic corps, looking to its greater systematization and effectiveness. Certain independent parties which had previously been under the immediate instruction of the director were assigned to duty under the chiefs of division, and the paleontologic corps was increased by the acquisition of Dr. W. H. Dall, formerly of the Coast and Geodetic Survey.

Vertebrates.—Prof. O. C. Marsh's personal work was confined to the preparation of the manuscript and illustrations of his volumes on the Dinocerata and the Sauropoda, and to the administrative duties of his division. The former monograph was about ready for publication at the end of the year. Early in the spring four field parties were sent out, two to the Jurassic beds of Wyoming, one to the same horizon in Colorado, and one to Northern Kansas. There was received from these parties during the year an unusually large amount of material. Their success in collecting Pliocene mammals in Kansas, and the remains of Dinosaurs in Colorado and Wyoming was marked—119 boxes having been taken from one locality in Kansas alone. Upon the approach of the winter season the collecting parties were transferred to Texas where the weather is such as to permit exploration throughout the entire year.

Paleozoic Invertebrates.—During the winter months Mr. C. D. Walcott, the chief of this division, was engaged in the preparation of a report on the Paleontology of the Eureka District, to accompany the monograph of Mr. J. S. Curtis on the Silver-Lead Deposits of this same region.

The plan of field work for the summer embraced the study by Mr. Walcott in person of the Cambrian system in Eastern New York and Western Vermont, including the preparation of numerous geologic sections and the collection of a large series of fossils; the continuance by Assistant Geologist Williams of his investigations in the Devonian and Lower Carboniferous in Western New York and Northern Pennsylvania on about the same plan as that pursued in 1883, and the sending out of collectors to obtain fossils from the Potsdam and Lower Magnesian formations of Wisconsin and Eastern Minnesota, and from the Cambrian of Northern Alabama. The latter part of this plan was satisfactorily carried out, but in the midst of his investigations in Vermont and New York Mr. Walcott was recalled, in conformity with the wish of the Honorable the Secretary of the Interior, who desired that a competent geologist of the Survey be designated to act as a member of a commission to examine supposed coal-bearing areas on the White Mountain Indian Reservation,

in Arizona. Upon the completion of the field work in connection with this duty, Mr. Walcott proceeded to Texas and made a brief study of the Paleozoic rocks in Burnet, Llano, San Saba, and Lampasas Counties. Though the study of these areas was limited, some very satisfactory results were obtained. After his return from the south it was too late to resume the investigations which he had abandoned in Vermont and New York.

On November 26 Mr. Walcott's report on the Deer Creek coal-fields of the San Carlos Indian Reservation was forwarded to the honorable the Secretary of the Interior.

Mesozoic Paleontology.—The paleontologic work of the division under the direction of Dr. C. A. White included the examination of the collections made by Mr. Becker on the Pacific coast. The successful completion of this task has already been noted in the reference to that division. Much preliminary work in connection with this duty was performed by Dr. White, and to this and to the study of his own collections he gave most of his time until his departure for the West in early June.

The arrangement of fossils for installation in the National Museum—a task which Dr. White superintends by reason of his curatorship in the National Museum—demanded much of the time and attention of his assistants during the winter season. This included the preparation of a catalogue of the type-specimens of this division for insertion in the report of the Director of the National Museum.

The preparation of an index-catalogue of the Mesozoic and Cenozoic fossils was undertaken by Dr. White, and such satisfactory progress made that it is believed its publication in 1885 will be possible.

On the opening of the field season and during the absence of Dr. White, collecting parties proceeded to such localities in the southern Appalachian District as contained formations which come under this division. On returning from California in September, Dr. White at once began the preparation of a report upon the Pacific coast collections. This was about completed at the close of the year.

Cenozoic Invertebrates.—A systematic study of the Invertebrates of the Quaternary has long been an unfilled want in the paleontologic work. In September the Survey was so fortunate as to secure the services of Dr. W. H. Dall, who immediately entered upon his duties. As a preliminary step, he began putting the large collections which had accumulated from time to time in such shape that while under study they can be utilized as a means of identification for incoming material. This task, in conjunction with the necessary attention to the routine duties connected with this division furnished work for several months.

Paleo-botany.—No field-work was undertaken by Prof. L. F. Ward during 1884, his large collections made heretofore occupying his entire time and attention. His especial line of study was the collections ob-

tained by him from the region of the Upper Mississippi, and the Yellowstone during the previous summer. In connection therewith he also undertook the compilation of a general compendium of paleobotany; substantially a digest of the history and present status of the science. Such a work, dealing largely with the literature of the subject, has come to be very important, if not indispensable to the proper utilization of American material in geologic work. The preliminary part of this volume, a sketch of paleobotany, illustrated with figures and tables, will appear in the Director's Fifth Annual Report.

Under Professor Ward's direction there was prepared a catalogue of the species of fossil plants in the National Museum, thus rendering the collection much more valuable for purposes of reference.

Prof. W. M. Fontaine's plan of work for the year was to continue his investigation of the Mesozoic fossil-plants by means of the material already collected until the opening of the field season, and then to make further collections from this formation in localities to the north and east of Fredericksburg, Va. The latter was successfully accomplished in a brief tour, and Professor Fontaine then returned to the elaborating of field-notes and the describing and figuring of type specimens.

Though engaged in the special line of work referred to, Professor Fontaine also made a careful study of the general geology of the regions visited in the course of his investigations. He believes that some of his discoveries will definitely determine the status of certain formations whose character have been considered uncertain.

CHEMISTRY.

The effectiveness of the laboratory service was greatly increased by the addition to the force of several experts and by the removal of the New Haven physical laboratory to Washington. This latter was rendered possible by the kindness of the director of the National Museum, who, as previously stated, permitted the laboratories to occupy the rooms in the Museum vacated by the office of the Director of the Survey. The fitting up of these rooms for this purpose was begun in October, and before the close of the year the combined forces of the two laboratories were busily at work again under Professor Clarke's direction.

During the year there were made a large number of analyses of mineral waters, sediments from mineral springs, minerals and clays, as well as a large number of assays of mineral-bearing ores. Original research was also prosecuted. This included new methods for the determination of titanium in rocks, for the determination of minute quantities of the precious metals in ores, and investigations concerning the precipitated silicates of lime, aluminum, and magnesium, this latter being fundamental to the study of the natural silicates.

Upon the opening of the field season Assistant Chemist Chatard proceeded to North Carolina for the purpose of obtaining specimens from

the corundum fields of that region, and Doctors Gooch and Hallock were sent to the Yellowstone National Park to make special studies of the geyser phenomena. Bulletins setting forth the results obtained will be issued in the due course of time.

In his capacity as a Curator of the National Museum, Professor Clarke gave considerable time and attention to the arrangement of the mineralogic collection to be exhibited at the New Orleans Exposition.

For some time prior to the removal of the physical laboratory from New Haven, experiments were made for the determination of high temperatures by means of thermo-electric couples. This line of research is of importance, opening up, as it does, a wider range of investigation than had heretofore been possible.

Before the close of the year there was sent to the press, a Bulletin by Dr. Carl Barus, on the Electric and Magnetic Properties of Iron-Carburets, the result of laboratory investigations.

The above reference to chemic work does not include analyses and special mineralogic studies made by such divisions of the Survey as it is not practicable to bring to Washington.

STATISTICS.

Mineral Resources of the United States.—As soon as it became practicable to begin the collection of statistics concerning the mineral resources of the United States other than gold and silver, the preparation of a second report was taken up by Mr. Albert Williams, jr. While this report follows the general form and scope of the previous volume, and is in itself complete, from a statistical and trade point of view, it complements the latter in the matter of description of localities, metallurgic processes, &c. A new feature will be the introduction of a series of graphic tables showing at a glance the progress in the several industries. While adding but a trifle to the cost of the publication, this scheme contributes greatly to its effectiveness.

At the close of the year the statistics for 1883 were in shape for printing, and progress made as far as possible in the collection of those for 1884. As soon as these are obtained the volume will be ready for the printer.

PUBLICATIONS.

Believing that it will prove of value to the many readers of the Smithsonian Report, for purposes of reference, there is appended hereto, in somewhat condensed form, the contents of the circular issued by the Survey concerning its publications.

The publications of the United States Geological Survey are issued in accordance with the statute approved March 3, 1879, which declares that—

"The publications of the Geological Survey shall consist of the annual report of operations, geological and economic maps illustrating the

resources and classification of the lands, and reports upon general and economic geology and paleontology. The annual report of operations of the Geological Survey shall accompany the annual report of the Secretary of the Interior. All special memoirs and reports of said survey shall be issued in uniform quarto series if deemed necessary by the Director, but otherwise in ordinary octavos. Three thousand copies of each shall be published for scientific exchanges and for sale at the price of publication; and all literary and cartographic materials received in exchange shall be the property of the United States, and form a part of the library of the organization: And the money resulting from the sale of such publications shall be covered into the Treasury of the United States."

On July 7, 1882, the following joint resolution, referring to all Government publications, was passed by Congress:

"That whenever any document or report shall be ordered printed by Congress, there shall be printed, in addition to the number in each case stated, the 'usual number' [1,900] of copies for binding and distribution among those entitled to receive them."

Under these general laws it will be seen that none of the Survey publications are furnished to it for gratuitous distribution. The 3,000 copies of the annual report are distributed through the document rooms of Congress. The 1,900 copies of each of the publications are distributed to the officers of the legislative and executive departments, and to stated depositories throughout the United States.

Except, therefore, in those cases where an extra number of any publication is supplied to this office by special resolution of Congress, as has been done in the case of the second, third, fourth, and fifth annual reports, or where a number has been ordered for its use by the Secretary of the Interior, as in the case of Mineral Resources, and Dictionary of Altitudes, the Survey has no copies of any of its publications for gratuitous distribution. The gratuitous edition of the Mineral Resources is entirely exhausted.

ANNUAL REPORTS.

Of the Annual Reports there have been already published:

I. First Annual Report to the Hon. Carl Schurz, by Clarence King. 1880. 8°. 79 pp. 1 map.—A preliminary report describing plan of organization and publications.

II. Report of the Director of the United States Geological Survey for 1880–'81, by J. W. Powell. 1882. 8°. lv, 558 pp. 61 pl. 1 map.

III. Third Annual Report of the United States Geological Survey, 1881–'82, by J. W. Powell. 1883. 8°. xviii, 564 pp. 67 pl. and maps.

IV. Fourth Annual Report of the United States Geological Survey, 1882–'83, by J. W. Powell. 1884. 8°. xii, 473 pp. 85 pl. and maps.

The edition of the Fourth Annual for the use of the Survey has not yet been delivered. The Fifth Annual is in press.

MONOGRAPHS.

Of the Monographs, Nos. II, III, IV, V, VI, and VII are now published, viz:

II. Tertiary History of the Grand Cañon District, with atlas, by Clarence E. Dutton, captain, U. S. A. 1882. 4°. 264 pp. 42 pl. and atlas of 26 double sheets folio, Price $10.12,

III. Geology of the Comstock Lode and the Washoe District, with atlas, by George F. Becker. 1882. 4°. xv, 422, pp. 7 pl. and atlas of 21 sheets folio. Price $11.

IV. Comstock Mining and Miners, by Eliot Lord. 1883. 4°. xiv, 451 pp. 3 pl. Price $1.50.

V. Copper-bearing Rocks of Lake Superior, by Roland D. Irving. 1883. 4°. xvi, 464 pp. 29 pl. Price $1.85.

VI. Contributions to the knowledge of the Older Mesozoic Flora of Virginia, by W. M. Fontaine. 1883. 4°. xi, 144 pp. 54 l. 54 pl. Price $1.05.

VII. Silver-lead Deposits of Eureka, Nevada, by Joseph S. Curtis. 1884. 4°. xiii, 200 pp. 16 pl. Price $1.20.

The following are in press, viz:

VIII. Paleontology of the Eureka District, by Charles D. Walcott. 1884. 4°. xiii, 285 pp. 24 l. 24 pl. Price $1.10.

IX. Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey, by Robert P. Whitfield. 1884. 4°. ix, 338 pp. 35 pl.

X. Dinocerata. A Monograph of an Extinct Order of Gigantic Mammals, by Othniel Charles Marsh. 1884. 4°. ———, ——— pp. ——— pl.

The following are in preparation, viz:

I. The Precious Metals, by Clarence King.

Geology and Mining Industry of Leadville, with atlas, by S. F. Emmons.

Geology of the Eureka Mining District, Nevada, with atlas, by Arnold Hague.

Lake Bonneville, by G. K. Gilbert.

Sauropoda, by Prof. O. C. Marsh.

Stegosauria, by Prof. O. C. Marsh.

BULLETINS.

The Bulletins of the Survey will contain such papers relating to the general purpose of its work as do not properly come under the heads of Annual Reports or Monographs.

Each of these Bulletins will contain but one paper, and be complete in itself. They will, however, be numbered in a continuous series, and will in time be united into volumes of convenient size. To facilitate this, each Bulletin will have two paginations, one proper to itself, and one which belongs to it as part of the volume.

Of this series of Bulletins, Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 are already published.

1. On Hypersthene-Andesite and on Triclinic Pyroxene in Augitic Rocks, by Whitman Cross, with a Geological Sketch of Buffalo Peaks, Colorado, by S. F. Emmons. 1883. 8°. 42 pp. 2 pl. Price 10 cents.

2. Gold and Silver Conversion Tables, giving the coining value of Troy ounces of fine metal, &c., by Albert Williams, jr. 1883. 8°. ii, 8 pp. Price 5 cents.

3. On the Fossil Faunas of the Upper Devonian along the meridian of 76° 30′, from Tompkins County, New York, to Bradford County, Pennsylvania, by Henry S. Williams, 1884. 8°. 36 pp. Price 5 cents.

4. On Mesozoic Fossils, by Charles A. White. 1884. 8°. 36 pp. 9 pl. Price 5 cents.

5. A Dictionary of Altitudes in the United States, compiled by Henry Gannett. 1884. 8°. 325 pp. Price 20 cents.

6. Elevations in the Dominion of Canada, by J. W. Spencer. 1884. 8°. 43 pp. Price 5 cents. ——. This number completes Vol. I of the Bulletins, and contains the title-page, table of contents, and list of illustrations for the whole volume.

7. Mapoteca Geologica Americana. A catalogue of geological maps of America (North and South), 1752–1881, by Jules Marcou and John Belknap Marcou. 1884. 8°. 184 pp. Price 10 cents.

8. On Secondary Enlargements of Mineral Fragments in certain Rocks, by R. D. Irving and C. R. Vanhise. 1884. 8°. 56 pp. Price 10 cents.

9. A Report of Work done in the Washington Laboratory during the fiscal year

1883-'84. F. W. Clarke, chief chemist; T. M. Chatard, assistant. 1884. 8°. 40 pp. Price 5 cents.

10. On the Cambrian Faunas of North America. Preliminary studies, by Charles D. Walcott. 1884. 74 pp. 10 pl. Price 5 cents.

The following are in press, viz:

11. On the Quaternary and Recent Mollusca of the Great Basin, with descriptions of new forms, by R. Ellsworth Call; introduced by a Sketch of the Quaternary Lakes of the Great Basin, by G. K. Gilbert. 1884. 8°. 66 pp. 6 pl.

12. A Crystallographic Study of the Thinolite of Lake Lahontan, by Edward S. Dana. 1884. 8°. 34 pp. 3 pl.

13. Boundaries of the United States and of the several States and Territories, by Henry Gannett. 1885. 8°. —— pp.

14. The Electrical and Magnetic Properties of the Iron-Carburets, by Carl Barus and Vincent Strouhal. 1885. 8°. —— pp.

15. Notes on the Mesozoic and Cenozoic Paleontology of California, by Charles A. White. 1885. 8°. —— pp.

16. The Higher Devonian Faunas of Ontario County, New York, by J. M. Clark. 1885. 8°. —— pp. 3 pl.

STATISTICAL PAPERS.

A fourth series of publications, having special reference to the mineral resources of the United States, is contemplated.

Of that series the first has been published, viz:

Mineral Resources of the United States, by Albert Williams, jr. 1883. 8°. xvii, 813 pp. Price 50 cents.

The second will shortly be ready for publication, viz:

Mineral Statistics of the United States, 1883-'84.

COLLECTIONS.

During the year the collections of the Survey were increased by the addition of 317 boxes of rocks, minerals, and fossils. This does not include the collections received at New Haven by Professor Marsh; nor the material collected by certain of the divisions of the Survey having permanent headquarters elsewhere than in Washington, and held by them temporarily for study.

UNITED STATES FISH COMMISSION.

As in previous years, I include in my report to the Board of Regents the principal facts connected with the work prosecuted by the United States Fish Commission during each year, as, under the appointment of the President, I exercise the function of United States Fish Commissioner. It is not necessary to go into any special detail in this connection, as the Reports and the Bulletins of the Commission contain a full account of progress during the year. The reports for 1882 and 1883 bring the subject up to the end of the latter year; and the continuation for 1884 consists, for the most part, in carrying out the plans already initiated in some respects on a larger scale.

Owing to the peculiarities of the season, the yield of eggs at the shad-hatching stations near Washington was not as productive as in previous years. The young shad hatched from these eggs were care-

fully distributed at many distant points, where they will no doubt exercise a very important function in connection with the stocking of the rivers of the Atlantic and Gulf coasts with shad.

The calls upon the Commission for the German carp have continued to increase, and have been met as far as the stock at command would allow. Twice the number of fish bred in the ponds in Washington could have been disposed of had they been in our possession.

The two cars constructed expressly for the purpose of transporting the fish to different parts of the country have proved extremely serviceable; and Congress authorized the building of a third car, which will be available in the early part of 1885. This contains many improvments over the others, and will be of great value in the work of the Commission.

The distribution of eggs of the Penobscot and land-locked salmon from the stations in Maine has been satisfactory, as in former years, the product of the stations being forwarded to such points in the United States as promise to be the most suitable.

In no year since the establishment of the Commission have there been so many eggs of whitefish taken at the two stations in Michigan, about one hundred and fifty millions being the actual yield. This fish is growing in favor, and there are numerous demands for it.

A large increase has been made in the distribution of the California trout, a fish that promises to be of great service in localities where the common brook-trout of the Eastern States cannot be maintained in proper condition.

The usual annual Bulletin of the United States Fish Commission has been published, making the fourth volume in the series. It contains many interesting communications which are very much sought after.

In previous reports mention has been made of the seacoast station at Wood's Holl, a point specially adapted for carrying out the work of the United States Fish Commission.

After having devoted a number of years to the improvement of the river fisheries of the United States, especially those of the salmon, shad, whitefish, &c., attention was turned to the fish inhabiting the ocean, with a view of determining the possibility of multiplying them to a profitable degree. The first experiments in this direction were mostly made at Gloucester, Mass., in the winter of 1878–'79, and were so satisfactory, in spite of the inclemency of the winter weather, during which the work is carried on, that it was determined, as soon as a suitable site could be obtained on the south coast of New England, to prosecute the work there on a large scale.

Wood's Holl combining all the requirements in a greater degree than could be found elsewhere, the first subject to be taken into consideration was that of acquiring the ground on which to erect the buildings. This was done by the liberality of several citizens of Massachusetts, and of the Old Colony Railroad Company, supplemented by contribu-

tions from various collegiate establishments which desired to utilize the expected opportunities in the interest of education. An appropriate strip of ground was thus secured and presented by the donors to the United States for use by the Commission. After the State of Massachusetts had formally ceded its jurisdiction the donation was accepted and an appropriation made for the necessary buildings. A concurrent appropriation, in the interests of commerce and navigation, for the construction of a harbor of refuge, and expended by the Engineer Bureau, was found to embrace all the requirements for locality, and the station as now organized comprises a hollow basin of about an acre in extent, in which pens and inclosures for fish can be made; and a wharf outside forming a suitable landing-place for coaling vessels, etc. An abundance of fresh water, and in addition an unlimited supply of salt water, complete the desiderata.

The building for the accommodation of persons connected with the Commission is completed, and was occupied during the past summer, and the fish-hatchery and laboratory will be ready for the season of 1885.

The work of hatching codfish is now under way, with promise of entire success.

The inquiries of the Commission in connection with the occurrence on the coast and their distribution of useful fishes, mollusks, &c.; its investigations into the character of the sea-bottom, and its suggestions as to its ability to support sea fishes, furnish large numbers of specimens of a great variety of species. These are carefully investigated by specialists connected with the Commission, and minutely detailed and described in its reports. After making selections for the benefit of the National Museum the duplicates are assorted, labeled, and made up into sets for distribution to colleges and academies. The number of sets already distributed amounts to several hundreds, the specimens in each set being carefully identified and labeled. No more acceptable contribution could be made to a college or academy, in view of the absolute impossibility of obtaining such objects from any other source, even without regard to cost.

The opportunities afforded at the sea-coast stations of the Commission for scientific research have, for many years, induced the presence of some of the most distinguished specialists in natural history and biology in this country, and many more persons apply for a share in the benefits than can be accommodated, although the material collected is usually in sufficient abundance for the needs of a large number of inquirers.

In order to utilize the surplus material and facilities of the Wood's Holl station in the interest of such parties it was thought desirable to obtain control of a tract of about two acres of ground immediately adjacent to the premises of the Commission, and in every way suitable for the erection of supplemental buildings, in which outside students could be accommodated and find the necessary facilities for work without interfering with the operations of the Commission. A friend of science accordingly

purchased ground at a cost of about $2,500, and holds it for future action. It is proposed to subdivide this into six lots, and to furnish the use of these lots to as many scientific establishments in the country as can be accommodated, all the expenses of erection of the necessary buildings and their maintenance to be cared for by the establishments in question.

A question, however, has arisen as to the control of the ground so as to secure proper co-ordination of action on the part of tenants, and prevent any use other than for the purely scientific purposes originally contemplated.

The owner of the ground, desiring to secure permanent supervision over it, wishes to deed it to the Smithsonian Institution, and I respectfully refer the subject to the Board for its action.

No money, either now or hereafter, is asked or expected from the Institution, but simply that it shall administer the trust referred to as coming strictly within its province—that of the "increase and diffusion of knowledge among men."

Respectfully submitted,

SPENCER F. BAIRD,

Secretary Smithsonian Institution.

WASHINGTON, *January*, 1885.

APPENDIX TO THE SECRETARY'S REPORT.

REPORT ON SMITHSONIAN EXCHANGES FOR 1884.

BY GEORGE H. BOEHMER.

One of the principal events of the year was the removal from a temporary location in the central hall of the Smithsonian building to the new quarters assigned in the east wing of the reconstructed fire-proof portion of the building, taking place in the month of March, 1884. This removal caused a temporary cessation of active operations, and consequently a not inconsiderable accumulation of material, which, together with the regular increase, crowded into the last nine months of the year an unusual amount of work. Furthermore, my appointment to visit Europe on business of exchange, and consequent absence since July—during which time Mr. N. P. Scudder assumed the duties of my position additional to his regular work as assistant in charge of the domestic branch of the exchanges—diminished the active force of the department; but notwithstanding all these disadvantages, the zealous and efficient application of the various assistants to their respective duties enabled them to overcome the obstacles, and to place the bureau in a position to enter upon the work of a new year without any accumulation.

The Record Division.—The duties of this office, as specified in the report for 1883, have been performed by Miss J. C. Diebitsch in a commendable manner, and notwithstanding the large increase in the work, the card catalogue alone now embracing 4,000 cards against 1,000 in 1883, and other multiplications of work—the files and records in this division have been posted promptly and accurately, so as to admit of momentary inspection of the accounts of exchanges kept with the various foreign establishments—an advantage claimed for the system when its acceptance was urged.

Foreign Exchange Division.—In February, owing to the transfer of the assistant in charge of this branch of the service, Mr. F. V. Berry was appointed in this place, and it is due to his energy and untiring application to his duties that the unusual accumulations and constant increase had been disposed of before the close of the year.

During the year 18,886, packages, with an aggregate weight of 78,732 pounds, have been received—an increase of 800 packages over the year 1883—which were sent in 537 boxes, this being 120 boxes more that in 1883. A detailed statement is presented in the appended general statistics.

Domestic Exchange Division.—As stated in the introductory, Mr. Scudder, the assistant in charge of this branch, had been appointed to assume the duties of the office during my absence in Europe on business of exchanges. Of the work performed in this division, I submit Mr. Scudder's report, as follows:

"The number of packages received and distributed to the United States during the year 1884 was 10,236. Of these 8,094 were sent to societies and 2,142 to individuals.

"The number of packages distributed by the domestic exchange during the year 1883 is somewhat (704) larger than the above, because of a slight modification of the scope of this branch of the exchange.

"During the year 1883 packages for Canada were forwarded by the domestic exchange, whereas in 1884 they were forwarded by the foreign exchanges. Again, in 1883 and the first eight months of 1884, all books for the Smithsonian Institution, whether received by mail or otherwise, were entered on the exchange records, but for the last four months of 1884 all books for the Smithsonian Institution coming by mail were sent direct to the Smithsonian Institution library without passing through the exchanges."

Government Exchange Division.—In last year's report the suggestions made in 1882, of placing this work in the hands of one assistant, to the exclusion of any other duty, has been, in part at least, inaugurated. A card catalogue has been prepared, and a clerk is intrusted with the proper management of this duty, in addition to such other work as may become necessary, like copying, &c., while the receiving and shipping is still done by the assistant in charge of the foreign branch.

During the year the Government of England has agreed to a complete exchange of all official documents, commencing with the 1st of January, 1882, and preliminary arrangements have been made to the same effect with the Government of Austria.

The receipts in this branch during the year are 22 boxes and 38,337 packages, with an aggregate of 32,827 pounds, while the transmissions to foreign governments amount to 114 boxes, against 76 boxes in 1883.

RECEIPTS.

1. *For foreign transmission.*

Whence received.	1884. Number of packages.	1884. Weight in pounds.
a. From Government Departments:		
Agricultural Department	446	1,114
Botanical Garden	3	31
Bureau of Ethnology	486	3,401
Census Office	1	9
Coast Survey	3	31
Comptroller of the Currency	1,000	1,060
Court of Claims	36	94
Department of Justice	1	1
Engineer Bureau, United States Army	136	2,127
Fish Commission	809	3,327
Geological Survey	1,689	9,331
Interior Department	95	801
National Museum	329	2,589
Nautical Almanac	1	5
Navy Department	2	7
Naval Observatory	221	904
Ordnance Office, United States Army	27	155
Patent Office	133	18,380
Signal Office, United States Army	1,969	11,580
Surgeon-General's Office, United States Army	52	496
Treasury Department	2	7
War Department	35	326
Total	7,476	55,776
b. From Smithsonian Institution	4,102	11,985
c. From societies, etc.:		
American Association for the Advancement of Science	32	284
American Entomological Society	19	20
American Geographical Society	2	39
American Journal of Arts and Sciences	165	56
American Philosophical Society	489	586
Boston Academy of Arts and Sciences	294	935
Boston Athenæum	1	19
Boston Society of Natural History	325	760
Buffalo Society of Natural History	105	52
Bussey Institution	22	10
Canadian Institute	135	146
Cincinnati Observatory	96	35
Cincinnati Society of Natural History	18	20
City Library, Baltimore	2	7
Commonwealth of Massachusetts	1	15
Davenport Academy of Natural Science	169	150
Franklin Institute, Philadelphia	1	35
Harvard College, Cambridge	2	7
Health Department, Baltimore	2	6
Johns Hopkins University	22	136
Museum of Comparative Zoology, Cambridge	213	507
Michigan State Board of Agriculture	33	153
National Academy of Science, Washington	325	800
National Deaf Mute Institute	1	10
New York Academy of Science	385	384
Numismatic and Antiquarian Society	211	70
Ohio Geological Survey	7	48

RECEIPTS—Continued.

For foreign transmission—Continued.

Whence received.	1884.	
	Number of packages.	Weight in pounds.
c. From societies, etc.—Continued.		
Ohio State Library	1	24
Pennsylvania Historical Society	71	71
Philadelphia Academy of Natural Science	63	347
Royal Society of Canada	55	500
Second Geological Survey of Pennsylvania	63	676
Saint Louis Academy of Science	269	253
United States Publishing Company, Philadelphia	1	808
University of New York	18	133
Vermont State Library	1	7
Washburn Observatory	267	615
Washington Anthropological Society	371	364
Washington Philosophical Society	139	125
Wisconsin Academy of Science	2	5
Miscellaneous societies	2,562	869
Total	6,960	10,087
d. From individuals	328	884
Grand total	18,866	78,732

2. *For domestic transmission.*

From—	1884.		
	Boxes.	Packages.	Weight.
Argentine Confederation	3	106	1,040
Belgium	12	644	1,300
Brazil	2	45	320
British India	1	1	16
Central America	2	7	430
Denmark	3	88	293
France	18	1,125	4,401
Great Britain and Ireland	76	1,891	14,263
Germany and Austria-Hungary	35	2,234	8,881
Italy	5	452	1,896
Labrador	31	31	3,765
Mexico	2	218	180
Netherlands	5	417	1,461
New South Wales	3	27	229
Norway	3	121	516
Peru	1	12	160
Russia	7	357	1,270
South Australia	1	23	90
Sweden	4	7	678
Switzerland	1	154	217
United States of Colombia	4	4	800
Victoria	1	1	35
West Indies	1	2	14
Total	221	7,967	42,255

3. *For Government exchanges.*

For what and whence received.	1884.		
	Boxes.	Packages.	Weight.
a. For Library of Congress from—			
England	18	18	2,799
Germany	2	2	600
Miscellaneous	....	65	118
Norway	1	1	225
Victoria	1	1	35
b. For foreign transmission from—			
Public Printer	....	38,250	29,050
Total	22	38,337	32,827

RECAPITULATION.

For what and whence received.	1884.		1883.	
	Packages.	Weight.	Packages.	Weight.
1. For foreign transmission from—				
Government Departments	7,476	55,776	7,165	44,637
Smithsonian Institution	4,102	11,985	6,218	22,566
Scientific societies	6,961	10,122	3,900	11,003
Individuals	327	849	780	441
	18,866	78,732	18,063	78,647
2. For domestic transmission	7,967	42,255	8,263	49,608
3. For Government exchanges	38,337	32,827	37,569	27,395
Total	65,170	153,814	53,849	155,650

In the year 1881 special attention was invited to the large increase in the reception of exchange parcels, the number for that year, 1881, being 43,104; in 1882 this had increased to 58,047; in 1883 to 63,894; and in 1884 to 65,170. In the report for 1882 it was respectfully suggested that the receiving and distributing of all the incoming exchanges be made a separate division of the service, and placed in the hands of a tried competent assistant, since on the prompt and accurate performance of this duty depends the punctuality of shipments of foreign, domestic, and Government document exchanges.

Taking the present status of incoming parcels, we now receive on an average over 200 parcels per day. These have to be assorted, arranged, compared with the invoice—if such has been furnished, otherwise an invoice has to be prepared—provided with the number corresponding to the respective address in the list of foreign correspondents and in the card catalogue, and distributed in the bins to await their turn of shipment. Thus far this work has been performed—mostly at the expense

of other important duties—by the assistants of the respective departments to whom such incoming parcels are referred, and it is from these considerations that the suggestion is now renewed and urged that this branch of the service be placed in charge of an assistant, while an additional clerk be employed to prepare, under his supervision, the then remaining only mechanical portion of the foreign exchanges, the shipping.

TRANSMISSIONS.

1. *Foreign transportations.*

An unusual number of boxes have been shipped during the year, the increase over last year being 120, while from 1882 to 1883 an increase of 70 boxes only was noticed. The following table furnishes a comparison with former years:

Items.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.
Boxes	397	309	311	268	407	422	495	651
Bulk (cub. ft.)	2,779	2,160	2,177	1,976	2,800	2,950	3,288	4,281
Weight, in lbs.	99,250	69,220	69,975	60,300	100,750	105,500	122,265	159,235

The distribution in 1884 was made as follows:

Country.	Government boxes.	Smithsonian boxes.	Total.
AFRICA.			
Algeria	....	3	3
Egypt, &c	....	4	4
Total	....	7	7
AMERICA.			
North America:			
British America	6	8	14
Mexico	3	8	11
West Indies:			
Cuba	....	2	2
Hayti	3	....	3
Jamaica	....	1	1
South America:			
Argentine Confederation	6	4	10
Brazil	3	5	8
British Guiana	....	1	1
Chili	3	2	5
Dutch Guiana	....	1	1
Paraguay	....	1	1
Peru	....	1	1
United States Colombia	3	2	5
Uruguay	....	1	1
Venezuela	3	....	3
Total	30	37	67

Distribution in 1884—Continued.

Country.	Government boxes.	Smithsonian boxes.	Total.
ASIA.			
China	....	3	3
India	3	6	9
Japan	3	9	12
Total	6	18	24
AUSTRALASIA.			
New South Wales	3	8	11
New Zealand	3	6	9
Queensland	3	2	5
South Australia	3	2	5
Tasmania	3	2	5
Victoria	3	5	8
Total	18	25	43
EUROPE.			
Austria-Hungary	3	25	28
Bavaria*	3	....	3
Belgium	3	42	45
Denmark	3	8	11
England	3	85	88
France	3	82	85
Germany	3	61	64
Greece	3	1	4
Italy	3	50	53
Netherlands	3	15	18
Norway	3	10	13
Portugal	3	8	11
Prussia*	3	....	3
Russia	3	25	28
Saxony*	3	....	3
Spain	3	7	10
Sweden	3	11	14
Switzerland	3	12	15
Turkey	3	7	10
Würtemberg*	3	....	3
Total	60	449	509
POLYNESIA.			
Oahu	....	1	1

RECAPITULATION.

Africa	....	7	7
America	30	37	67
Asia	6	18	24
Australasia	18	25	43
Europe	60	449	509
Polynesia	....	1	1
Total	114	537	651

* The Smithsonian exchanges are included in the cases for Germany.

TRANSPORTATION COMPANIES.

The privilege of free freight on parcels and boxes bearing the stamp of the Smithsonian Institution has been continued during the past year on the part of the following:

Anchor Steamship Company (Henderson & Bro., agents), New York.

Atlas Steamship Company (Pim, Forwood & Co., agents), New York.

Bailey, H. B., & Co., New York.

Biddle, E. R., Philadelphia.

Bixby, Thomas, & Co., Boston.

Bland, Thomas, New York.

Borland, B. R., New York.

Cameron, R. W., & Co., New York.

Compagnie Générale Transatlantique (L. de Bébian, agent), New York.

Cunard Royal Mail Steamship Line (Vernon Brown & Co., agents), New York.

Dallett, Boulton & Bliss, New York.

Dennison, Thomas, New York.

Hamburg-American Packet Company (Kunhardt & Co., agents), New York.

Inman Steamship Company, New York.

Merchants' Line of Steamers, New York.

Monarch Line (Patton, Vickers & Co., agents), New York.

Muñoz y Espriella, New York.

Murray, Ferris & Co., New York.

Netherlands-American Steam Navigation Company (H. Cazaux, agent), New York.

New York and Brazil Steamship Company, New York.

New York and Mexico Steamship Company, New York.

North German Lloyd (Oelrichs & Co.), New York; Schumacher & Co., Baltimore, agents.)

Pacific Mail Steamship Company, New York.

Panama Railroad Company, New York.

Red Star Line (Peter Wright & Sons, agents), Philadelphia and New York.

Spinney, Joseph S., New York.

Steamship Line for Brazil, Texas, Florida, and Nassau, N. P. (C. W. Mallory & Co., agents), New York.

White Cross Line (Funch, Edye & Co., agents), New York.

Wilson & Asmus, New York.

In addition to these regularly established transportation companies, the consuls of foreign powers in the United States have volunteered or agreed to take charge of the transmission of Smithsonian exchanges to the following countries:

Argentine Republic, Carlos Carranza, New York.

Brazil, Charles Mackall, Baltimore.

[illegible]

[illegible]		637
[illegible]		,052
[illegible]		987
[illegible]		1,445
[illegible]		1,245
[illegible]		1,273
[illegible]		1,539
[illegible]		1,933
[illegible]		1,908
[illegible]		1,406
[illegible]		2,111
[illegible]		1,522
[illegible]		2,482
[illegible]		2,368
[illegible]		2,703
[illegible]		971
[illegible]		2,394
[illegible]		4,130
[illegible]		3,705
[illegible]		3,952
[illegible]		4,635
[illegible]		4,782
[illegible]		4,326
[illegible]		4,661
[illegible]		4,853
[illegible]	[illegible]	4,962
[illegible]	2	5,292
[illegible]	5	6,971
[illegible]	15	5,587
[illegible]	54	8,433
[illegible]	947	8,359
[illegible]	894	11,000
[illegible]	770	10,236
	5,897	124,360

Shipping list, &c.—Continued.

Country.	Shipping agent.
France	Compagnie Générale Transatlantique, New York.
Germany	North German Lloyd, New York or Baltimore. Hamburg-American Packet Company.
Great Britain	Monarch Line, New York. North German Lloyd, New York or Baltimore. Cunard Royal Mail Steamship Company. Inman Steamship Company, New York.
Greece	Consul D. W. Botassi, New York.
Guatemala	Consul Jacob Baez, New York.
Hayti	Atlas Steamship Company, New York.
Iceland	Consul Thomas Schmidt, New York; transfer made by the Kongelige Danske Videnskabernes Selskab, Copenhagen.
India	Monarch Line, New York; transfer made by Secretary of State for India, India Office, London, England.
Italy	Consul-General M. Raffo, New York.
Japan	Consul Samro Takaki, New York.
Liberia	American Colonization Society, Washington, D. C.
Madeira Malta Mauritius Mozambique	Monarch Line, New York; transfer made by Crown agents for the colonies, London, England.
Mexico	Consul J. N. Navarro, New York.
Netherlands	Consul W. H. van den Toorn, New York.
Netherlands India	Consul W. H. van den Toorn, New York; transfer made by Bureau Scientifique Central Néerlandais, Haarlem, Holland.
New Caledonia	Monarch Line, New York; transfer made by W. Wesley to Gordon & Gotch, London, England.
New South Wales	Monarch Line, New York; transfer made by agent-general for New South Wales, London.
New Zealand	Monarch Line, New York; transfer made by agent-general for New Zealand, London, England.
Nicaragua	Consul-General Alexander I. Cotheal, New York.
Norway	Consul Christian Börs, New York.
Paraguay	Consul John Stewart, Washington, D. C.
Peru	Joseph S. Spinney, New York.
Philippine Islands	Spanish consul, San Francisco.
Polynesia	Consul Severance, San Francisco.
Portugal	Consul Gustav Amsink, New York.
Queensland	Monarch Line, New York; transfer made by Queensland department, London, England.
Russia	Hamburg-American Packet Company, New York; transfer made by Russian consul-general, Hamburg, Germany.
St. Helena	Monarch Line, New York; transfer made by the Crown agents for the colonies, London, England.
Siam	Consul Isaac T. Smith, New York.
South Australia	R. W. Cameron & Co., New York.
Spain	Consul-general, New York.
Straits Settlements	Monarch Line, New York; transfer made by the Crown agents for the colonies, London, England.
Sweden	Consul Christian Börs, New York.
Switzerland	North German Lloyd, Baltimore; transfer made by Swiss consul in Bremen, Germany.
Syria	Presbyterian Rooms, New York.
Tasmania	Monarch Line, New York; transfer made by the Crown agents for the colonies, London, or by G. W. Wheatley & Co., London, England.
Turkey	Consul Edouard Scherer, New York.
Turk's Island	Wilson & Asmus, New York.
Uruguay	Ambassador Enrique Estrázulas, New York.
Venezuela	Dallett, Boulton & Bliss, New York.
Victoria	Monarch Line, New York; transfer made by agent-general for Victoria, London, England.
West Indies	H. B. Bailey & Co., New York.

CENTERS OF DISTRIBUTION.

Countries.	Agencies.
Algeria	M. Canette, chef d'état major du génie, service météorologique, Algiers.
Argentine Confederation	Museo Público, Buenos Ayres.
Austria-Hungary	Dr. Felix Flügel, Leipsic.
Belgium	Commission Belge Échange Internationaux, Brussels.
Brazil	Commissão Central Brazileira de Permutações Intercionães, Rio Janeiro.
British America	McGill College, Montreal. Geological Survey, Ottawa.
British Guiana	Observatory, Georgetown.
Cape Colonies	Agent general for Cape Colony, London, England.
Chili	Universidad, Santiago.
China	Crown agents for the colonies, London, England. United States consul-general, Shanghai.
Colombia, United States of	Central Commission of Exchanges, National Library, Bogotá.
Costa Rica	Universidad, San José.
Denmark	K. D. Videnskabernes Selskab, Copenhagen.
Dutch Guiana	Surinaamsche Koloniaale Bibliotheek, Paramaribo.
Ecuador	Observatorio del Colegio Nacional, Quito.
Egypt	Institut Égyptien, Cairo.
Finland	Kejserliga Alexanders Universitet, Helsingfors.
France	Bureau Français des Échanges Internationaux, Paris.
Germany	Dr. Felix Flügel, Leipsic.
Great Britain	William Wesley, London.
Greece	National Library, Athens.
Guatemala	Sociedad Economica de Amigos del Pais, Guatemala.
Iceland	Islands Stiptisbokasafn, Reykjavik.
India	Secretary to Government of India, Home Department, Calcutta.
Italy	Biblioteca Nazionale Vittorio Emanuele, Rome.
Japan	Minister for Foreign Affairs, Tokio.
Liberia	Liberia College, Monrovia.
Madeira	Crown agents for the colonies, London, England.
Malta	Do.
Mauritius	Agent-general for Cape Colony, London, England.
Mozambique	Do.
Mexico	Señor Ministro de Justicia y Istruccion Publica, Mexico.
Netherlands Netherlands India	Bureau Scientifique Central Néerlandais, Haarlem.
New Caledonia	Gordon & Gotch, London.
New South Wales	Royal Society of New South Wales, Sydney.
New Zealand	Parliamentary Library, Wellington.
Nicaragua	Government, Managua.
Norway	K. N. Frederiks Universitet, Christiania.
Paraguay	Government.
Peru	Biblioteca Nacional, Lima.
Philippine Islands	Royal Economic Society, Manila.
Polynesia	Royal Hawaiian and Government Library, Honolulu.
Portugal	Escola Polytechnica, Lisbon.
Queensland	Government Meteorological Observatory, Brisbane.
Russia	Commission Russe des Échanges Internationaux, St. Petersburg.
St. Helena	Crown agents for the colonies, London, England.
South Australia	Astronomical Observatory, Adelaide.
Spain	R. Academia de Ciencias, Madrid.
Straits Settlements	Crown agents for the colonies, London, England.
Sweden	K. S. Vetenskaps Akademien, Stockholm.
Switzerland	Eidgenossensche Bundes Kanzlei, Berne.
Tasmania	Royal Society of Tasmania, Hobart.
Turk's Island	Public Library, Grand Turk.
Uruguay	Bureau de Statisque, Montevideo.
Venezuela	Universidad, Caracas.

CENTERS OF DISTRIBUTION—Continued.

Countries.	Agencies.
Victoria	Public Library, Melbourne.
West Indies:	
Cuba	R. Universidad, Havana.
Hayti	Sécrétaire d'État des Rélations Extérieures, Port-au-Prince.
Trinidad	Scientific Association, Port of Spain.

2. *Domestic transmissions.*

Ten thousand two hundred and thirty-six packages were received during the year and distributed within the United States as follows:

State.	No. of packages.	State.	No. of packages.
Alabama	4	Mississippi	1
Arkansas	4	Missouri	194
California	113	Nebraska	1
Colorado	1	New Hampshire	14
Connecticut	303	New Jersey	64
District of Columbia	5,713	New York	981
Florida	1	North Carolina	7
Georgia	8	Ohio	126
Illinois	122	Pennsylvania	611
Indiana	20	Rhode Island	46
Iowa	108	South Carolina	21
Kansas	2	Tennessee	6
Kentucky	11	Texas	2
Louisiana	19	Virginia	39
Maine	37	Vermont	13
Maryland	115	West Virginia	3
Massachusetts	1,342	Wisconsin	121
Michigan	40		
Minnesota	23	Total	10,236

A comparison with former years shows the following results:

Items.	1878.	1879.	1880.	1881.	1882.	1883.	1884.
Total addresses of institutions	292	444	385	600	548	423	409
Total addresses of individuals	370	341	560	454	399	471	361
Total number of parcels to institutions	4,059	5,786	4,021	7,086	7,192	8,697	8,094
Total number of parcels to individuals	1,233	1,185	1,566	1,347	1,167	2,323	2,142
Total number of packages	5,292	6,971	5,587	8,438	8,359	11,000	10,236

Among the packages enumerated in the above were 3,030 addressed to the Smithsonian Institution, and these contained 1,567 volumes, 10,393 parts and pamphlets, and 143 maps and engravings. Assuming the same ratio for the remaining parcels, it will be seen that about 40,000 books, pamphlets, &c., have been distributed within the United States during the past year.

The history and condition of domestic exchanges, from their commencement to the present time, are exhibited in the following table:

Year.	Received for the Smithsonian library.				For institutions and individuals in the United States and British America.	
	Volumes.	Parts and pamphlets.	Maps and engravings.	Total.	Addresses.	Packages.
1846–1850	470	624	4	1,098	....	....
1851	549	618	....	1,167	....	....
1852	1,481	2,106	1,749	5,336	96	637
1853	1,440	991	125	2,556	160	1,052
1854	926	1,468	434	2,826	149	987
1855	1,037	1,707	26	2,770	219	1,445
1856	1,356	1,834	140	3,330	189	1,245
1857	555	1,067	138	1,760	193	1,273
1858	723	1,695	122	2,540	243	1,539
1859	1,022	2,540	40	3,602	293	1,933
1860	1,271	4,180	220	5,671	335	1,908
1861	821	1,945	120	2,886	274	1,406
1862	1,611	3,369	55	5,035	273	2,111
1863	910	3,479	200	4,589	273	1,522
1864	823	2,754	109	3,686	299	2,482
1865	767	3,256	183	4,206	345	2,368
1866	1,243	4,509	121	5,873	329	2,703
1867	1,557	3,946	328	5,831	347	971
1868	1,770	3,605	134	5,509	436	2,394
1869	1,234	4,089	232	5,555	501	4,130
1870	1,113	3,890	179	5,182	567	3,705
1871	936	3,579	82	4,597	573	3,952
1872	1,262	4,502	198	5,962	587	4,635
1873	889	4,354	454	5,697	689	4,782
1874	863	4,521	162	5,546	750	4,326
1875	1,120	5,813	114	7,047	610	4,661
1876	1,017	6,193	375	7,585	644	4,853
1877	1,889	6,511	326	8,726	766	4,962
1878	1,263	7,392	74	8,729	662	5,292
1879	1,949	8,071	183	10,203	785	6,971
1880	1,143	7,275	152	8,570	945	5,587
1881	1,867	9,904	188	11,959	1,054	8,433
1882	1,296	10,341	152	11,789	947	8,359
1883	1,754	10,702	219	12,675	894	11,000
1884	1,567	11,149	143	12,859	770	10,236
Total	41,494	153,979	7,481	202,954	15,897	124,360

3. *Government transmissions.*

Three transmissions (Nos. 20, 21, 22) of 38 boxes each were made to foreign governments under the system of exchange inaugurated by acts of Congress of the 2d of March, 1867, and July 25, 1868. The countries now supplied with the government documents, together with the number of boxes sent since 1868, are exhibited in the following table:

Countries.	No. of boxes.	Countries.	No. of boxes.
Argentine Confederation	22	Netherlands	22
Bavaria	22	New South Wales	22
Belgium	22	New Zealand	22
Brazil	22	Norway	22
Buenos Ayres	22	Portugal	22
Canada (Ottawa)	22	Prussia	22
Canada (Ontario)	22	Queensland	22
Chili	22	Russia	22
Colombia, United States of	22	Saxony	22
Denmark	22	Scotland (discontinued in 1879)	12
France	22	South Australia	22
France, second set (discontinued in 1882)	16	Spain	22
Germany (Empire)	22	Sweden	22
Great Britain	22	Switzerland	22
Greece	22	Tasmania	22
Hayti	22	Turkey	25
Hungary	22	Venezuela	22
India	22	Victoria	22
Italy	22	Würtemberg	22
Japan	22	Total	864
Mexico	22		

The shipping to their destination of these cases of exchanges is performed in large part by the consuls accredited to the United States, namely:

Carlos Carranza, Argentine Confederation.
Charles Mackall, Brazil.
Justo R. de la Espriella, Chili.
Lino de Pombo, United States of Colombia.
Thomas Schmidt, Denmark.
D. W. Botassi, Greece.
M. Raffo, Italy.
J. N. Navarro, Mexico.
W. H. van den Toorn, Netherlands.
Christian Börs, Norway and Sweden.
Gustav Amsink, Portugal.
H. de Uriarte, Spain.
Ed. Scherer, Turkey.

The final disposition of the books comprised in this system of exchange has been made by the respective Governments, who have designated the establishments enumerated in the following list as depositories:

Governments.	Establishments designated for the reception of Government exchanges.
Argentine Confederation	Minister of Foreign Affairs, Buenos Ayres.
Bavaria	Königliche Bibliothek, Munich.
Belgium	Bibliothèque Royale, Brussels.
Brazil	Commission of International Exchanges, Rio Janeiro.
Buenos Ayres	Government, Buenos Ayres.
Canada	Parliamentary Library, Ottawa. Legislative Library, Toronto.
Chili	Bibliotheca Nacional, Santiago.
Colombia, United States of.	National Library, Bogota.
Denmark	Kongelige Bibliotheket, Copenhagen.
France	Bureau des Échanges Internationaux, Paris.
Germany	Bibliothek des Reichstags, Berlin.
Great Britain	British Museum, London.
Greece	Bibliothèque Nationale, Athens.
Hayti	Secrétaire d'État des Rélations Extérieures, Port-au-Prince.
Hungary	Präsidium des k. Ungarischen Ministeriums, Budapest.
India	Secretary to Government of India, Calcutta.
Italy	Biblioteca Nazionale Vittorio Emanuele, Rome.
Japan	Minister of Foreign Affairs, Tokio.
Mexico	National Library, Mexico.
Netherlands	Library of the States General, The Hague.
New South Wales	Parliamentary Library, Sydney.
New Zealand	Parliamentary Library, Wellington.
Norway	Foreign Office, Christiania.
Prussia	Königliche Bibliothek, Berlin.
Queensland	Government, Brisbane.
Russia	Commission Russe des Échanges Internationaux, St. Pétersburg.
Saxony	Königliche Bibliothek, Dresden.
South Australia	Government, Adelaide.
Spain	Government, Madrid.
Sweden	Government, Stockholm.
Switzerland	Eidgenossensche Bundes-Kanzlei, Berne.
Tasmania	Parliamentary Library, Hobart.
Turkey	Government Library, Constantinople.
Venezuela	Parliamentary Library, Caracas.
Victoria	Public Library, Melbourne.
Wurtemberg	Königliche Bibliothek, Stuttgart.

List of official publications received from the Public Printer during the year 1884.

AGRICULTURAL DEPARTMENT.

1884.

Jan. 2. Special Report No. 63. The grasses of the United States, being a synopsis of the tribes and genera, with descriptions of the genera, and a list of the species. Prepared by Dr. George Vasey, botanist of the Department of Agriculture. 8vo. Paper. 47 p.

Special Report No. 64. On condition of crops, "American competition," and freight rates of transportation companies. August 1, 1883. 8vo. Paper. 80 p.

Special Report No. 65. On condition of crops and on freight rates of transportation companies. September, 1883. 8vo. Paper. 55 p.

Jan. 10. Proceedings of a national convention of cattle-breeders and others, called in Chicago, November 15 and 16, 1883, by the Hon. George B. Loring, to consider the subject of contagious diseases of domestic animals. 8vo. Paper. 85 p.

1884.

June 30. Annual Report, 1883. 8vo. Cloth. 496 p.

Aug. 5. Microscopic observations, by Thomas Taylor, M. D. Internal parasites in domestic fowls. Butter and fats. 8vo. Paper.

Oct. 16. The agricultural grasses of the United States. By Dr. George Vasey, botanist of the Department of Agriculture. Also, the chemical composition of American grasses. By Clifford Richardson, assistant chemist. 120 plates. 8vo. Paper. 144 p.

Nov. 25. Contagious diseases of domestic animals. Investigations by Department of Agriculture, 1883-'84. 10 plates. 2 maps. 8vo. Paper. 368 p.

Chemical division.

Bulletin No. 1. An investigation of the composition of American wheat and corn. Clifford Richardson, assistant chemist. 8vo. Paper. 69 p.

June 30. Bulletin No. 2. Diffusion. Its application to sugar cane, and record of experiments with sorghum in 1883. H. W. Wiley, chemist. 8vo. Paper. 36 p.

Sept. 15. Bulletin No. 3. The northern sugar industry. A record of its progress during the season of 1883. W. H. Wiley, chemist. 11 plates. 8vo. Paper. 120 p.

Oct. 18. Bulletin No. 4. An investigation of the composition of American wheat and corn. Second report. Clifford Richardson, assistant chemist. 8vo. Paper. 98 p.

Oct. 28. Bulletin No. 4. An investigation of the composition of American wheat and corn. Second report. Clifford Richardson, assistant chemist. 8vo. Paper. — p.

Division of entomology.

June 1. Bulletin No. 3. Reports of observations and experiments in the practical work of the division, made under the direction of the entomologist, with plates. 8vo. Paper. 75 p.

June 30. Bulletin No. 4. Reports of observations and experiments in the practical work of the division. 8vo. Paper. 102 p.

Division of statistics.

June 1. Report No. 1. On condition of crops, yield of grain per acre, and on freight rates of transportation companies, October, 1883. 8vo. Paper. 28 p.

Report No. 2. On yield of crops per acre, on the progress of sorghum growing, the crops of Europe, and on freight rates of transportation companies. November, 1883. 8vo. Paper. 59 p.

Report No. 3. Of the crops of the year, of cereal production in Europe, and freight rates of transportation companies. December, 1883. 8vo. Paper. 74 p.

Report No. 4. Upon the numbers and values of farm animals, certain causes affecting wages of farm labor, and on freight rates of transportation companies. February, 1884. 8vo. Paper. 56 p.

June 30. Report No. 5. On the distribution and consumption of corn and wheat, and the rates of transportation of farm products. March, 1884. 8vo. Paper. 44 p.

Report No. 6. Of the acreage of winter grain, the condition of farm animals, and freight rates of transportation companies. April, 1884. 8vo. Paper. 48 p.

Report No. 7. Of the condition of winter grain, the progress of cotton planting, and estimates of cereals of 1883, with freight rates of transportation companies. May, 1884. 8vo. Paper. 36 p.

1884.

July 1. Report No. 8. Of acreage of spring grain and cotton, the condition of winter wheat, and European grain prospects, with freight rates of transportation companies. June, 1884. 8vo. Paper. 39 p.

21. Report No. 9. On the area of corn, potatoes, and tobacco, the condition of growing crops, and on the rates of transportation. July, 1884. 8vo. Paper. 59 p.

Aug. 16. Report No. 10. On the condition of growing crops and on rates of transportation. August, 1884. 8vo. Paper. 36 p.

Sept. 24. Report No. 11. On condition of crops, on wheat in India, and on freight rates of transportation companies. September, 1884. 8vo. Paper. 87 p.

Miscellaneous.

Special Report, No. 1. Forestry in the United States. Address of the Hon. George B. Loring, United States Commissioner of Agriculture, before the American Forestry Congress, Saint Paul, Minn., August 8, 1883. 8vo. Paper. 41 p.

Special Report No. 2. Proceedings of a convention of agriculturists, held at the Department of Agriculture, January 23, 24, 25, 26, 27, and 29, 1883. 8vo. Paper. 245 p.

June 30. Special Report No. 3. "Mississippi," its character, soil, productions, and agricultural capabilities. By A. B. Hunt. 8vo. Paper. 89 p.

July 1. Special report, No. 4. The climate, soil, physical resources, and agricultural capabilities of the State of Maine. By Samuel L. Boardman. 8vo. Paper. 60 p.

July 1. Special Report No. 5. Proper value and management of Government timber lands and the distribution of North American forest trees, being papers read at the United States Department of Agriculture, May 7–8, 1884. 8vo. Paper. 47 p.

Oct. 4. The Agricultural grasses of the United States. By Dr. George Vasey, botanist of the Department of Agriculture. Also, the chemical composition of American grasses. By Clifford Richardson, assistant chemist. 120 plates. 8vo. Paper. 144 p.

Dec. 13. Special Report No, 6. Address of Hon. George B. Loring, United States Commissioner of Agriculture, at the National Convention of Cattle-Breeders, Chicago, Ill., November 13, 1884. Also, the report of the veterinary inspectors in New York. 8vo. Paper. 21 p.

Oct. 24. Report on condition of crops, yield of grain per acre, and on freight rates of transportation companies. New series. Report No. 12. October, 1884. 8vo. Paper. 44 p.

Oct. 26. New Series. Report No. 10. On yield of crops per acre, on agriculture in Mexico, and on freight rates of transportation companies. November, 1884. 8vo. Paper. 94 p.

CIVIL SERVICE COMMISSION.

Jan. 10. Civil service act, amended rules and regulations. Third edition. 8vo. Paper. 20 p.

June 30. Same. Fourth edition. 8vo. Paper. 22 p.

June 30. First annual report. 8vo. Paper. 72 p.

Same. Second edition. 8vo. Paper. 74 p.

Sept. 22. Civil service act, amended rules and regulations. Fifth edition. 8vo. Paper. 22 p.

UNITED STATES CONGRESS.

1884.

June 30. Congressional Record, first session Forty-eighth Congress, 1883-1884. Vol. 15, part 1. 4to. Half Russia. 1008 p. Part 2, pages 1009-1216. Half Russia. 1008 p.

July 18. Congressional Record, vol. 15, part 3, pages 2017-3024, Forty-eighth Congress, first session, March 18 to April 16, 1884. 4to. Paper. 1008 p.

Aug. 7. Congressional Record, vol. 15, part 4, pages 3025-4240, Forty-eighth Congress, first session, April 16 to May 16, 1884. 4to. Paper. 1216 p.

Aug. 29. Congressional Record, vol. 15, part 5, pages 4241-5456, Forty-eighth Congress, first session, May 16 to July 21, 1884. 4to. Paper. 1216 p.

Sept. 17. Congressional Record, vol. 15, part 6, pages 5457-6182 and Appendix, Forty-eighth Congress, first session, June 21 to July 7, 1884. 4vo. Paper. 1232 p.

Sept. 17. Index to vol. 15, parts 1-6, Forty-eighth Congress, first session. 4to. Paper. 790 p.

House of Representatives.

Jan. 10. House reports, first session Forty-seventh Congress, 1881-'82, vol. 3, Nos. 654-993. 8vo. Sheep.

House miscellaneous, first session Forty-seventh Congress, 1881-'82, vol. 3. Contested election, Bisbee *v.* Finley. 8vo. Sheep. 1,227 p.

House miscellaneous, first session Forty-seventh Congress, 1881-'82, vol. 10. Contested election, Sessinghans *v.* Frost. Part 2. 8vo. Sheep.

House miscellaneous, first session Forty-seventh Congress, 1881-'82, vol. 6, Nos. 19 and 20. 8vo. Sheep.

Jan. 23. Digest and manual of the rules and practice of the House of Representatives (seventh edition), compiled by Henry H. Smith. 8vo. Paper. 472 p.

Jan. 30. Executive documents, first session Forty-seventh Congress, 1881-'82, vol. 26. Agricultural report, 1881-'82. 8vo. Sheep. 704 p.

Executive documents, third session Forty-sixth Congress, 1880-'81, vol. 7. Signal Office, No. 1. Part 2, vol. 4. 8vo. Sheep. 1,120 p.

Mar. 28. Executive documents, first session Forty-seventh Congress, 1881-'82, vol. 3. Engineers, No. 1, part 2, vol. 2. Part 1. 8vo. Sheep. 1,042 p.

House miscellaneous, second session Forty-seventh Congress, 1882-'83, vol. 2. Report of the tariff commission, vol. 1. 8vo. Sheep. 1,248 p.

House miscellaneous, second session Forty-seventh Congress, 1882-'83, vol. 2. Report of the tariff commission. 8vo. Sheep. 2,617 p.

House miscellaneous, second session Forty-seventh Congress, 1882-'83, vol. 9. Digest of election cases. 8vo. Sheep. 692 p.

House miscellaneous, second session Forty-seventh Congress, 1882-'83, vol. 10. Decisions of First Comptroller, vol. 3. 8vo. Sheep. 614 p.

Executive documents, second session Forty-seventh Congress, 1882-'83, vol. 15. Report on the finances. 8vo. Sheep. 589 p.

Executive documents, second session Forty-seventh Congress, 1882-'83, vol. 22. Offers for carrying the mail. 8vo. Sheep. 1,484 p.

June 30. Executive documents, first session Forty-seventh Congress, 1881-'82. 8vo. Sheep.

Executive documents, first session Forty-seventh Congress, 1881-'82, vol. 1. Foreign relations. 8vo. Sheep.

Executive documents, first session Forty-seventh Congress, 1881-'82, vol. 9. Interior and Land Office reports. 8vo. Sheep.

Executive documents, first session Forty-seventh Congress, 1881-'82, vol. 12, Education report. 8vo. Sheep.

1884.

June 30. Executive documents, first session Forty-seventh Congress, 1881–'82, vol. 21. Nos. 117–121. 8vo. Sheep.

Executive documents, second session Forty-seventh Congress. 8vo. Sheep.

Executive documents, second session Forty-seventh Congress, vol. 3. Navy Department report. 8vo. Sheep.

July 1. Executive documents, third session Forty-sixth Congress, vol. 17. Report of National Board of Health. 8vo. Sheep. 646 p.

Executive documents, first session Forty-seventh Congress, vol. 6. Ordnance, No. 1. Part 2, vol. 3. 8vo. Sheep. 560 p.

June 30. House reports, first session Forty-seventh Congress, 1881–'82. 8vo. Sheep.

House reports, first session Forty-seventh Congress, vol. 2. Nos. 393–653. 8vo. Sheep.

House reports, first session Forty-seventh Congress, vol. 4. Nos. 994–1276. 8vo. Sheep.

House reports, second session Forty-seventh Congress, vol. 1. Nos. 1812–1958. 8vo. Sheep.

House reports, second session Forty-seventh Congress, vol. 2. Nos. 1959–2044. 8vo. Sheep.

House reports, first session Forty-seventh Congress, vol. 5. General index of the Journals of Congress from Eleventh to Sixteenth Congress, inclusive. 4to. Sheep. 118 p.

House miscellaneous, first session Forty-seventh Congress, 1881–'82. 8vo. Sheep.

House miscellaneous, first session Forty-seventh Congress, vol. 4, Nos. 14 and 15. 8vo. Sheep.

House miscellaneous, first session Forty-seventh Congress, vol. 5, Nos, 16, 17, 18, 21. 8vo. Sheep.

House miscellaneous, first session Forty-seventh Congress, vol. 7. Contested election, Lowe *v.* Wheeler. 8vo. Sheep.

House miscellaneous, first session Forty-seventh Congress, vol. 18. Rebellion Records, vol. 5. 8vo. Sheep.

House miscellaneous, first session Forty-seventh Congress, vol. 23. Rebellion Records, vol. 6. 8vo. Sheep.

House miscellaneous, first session Forty-seventh Congress, vol. 27. Rebellion Records, vol. 7. 8vo. Sheep.

House miscellaneous, second session Forty-seventh Congress, 1881–'82. 8vo. Sheep.

House miscellaneous, second session Forty-seventh Congress, 1881–'82, vol. 1, Nos. 1–18, exclusive 6 and 9. 8vo. Sheep.

House miscellaneous, second session Forty-seventh Congress, 1881–'82, vol. 6. Rebellion Records, vol. 8. 8vo. Sheep.

House miscellaneous, second session Forty-seventh Congress, 1881–'82, vol. 11, Nos. 39 and 40. 8vo. Sheep.

House miscellaneous, second session Forty-seventh Congress, 1881–'82, vol. 12. Rebellion Records, vol. 9. 8vo. Sheep.

House miscellaneous, second session Forty-seventh Congress, 1881-'82, vol. 8. Eulogies, Lowe, Updegraff, Orth, Hawk, Shackelford. 4to. Sheep.

House miscellaneous, second session Forty-seventh Congress, 1881–'82, vol. 13. Tenth Census United States, vol. 1. 4to. Sheep.

House miscellaneous, first session Forty-seventh Congress, 1882–'83, vol. 19, Nos. 59, 60. 8vo. Sheep.

July 1. Executive documents, second session Forty-seventh Congress, vol. 21, Nos. 73 to 104, inclusive, except No. 93. 8vo. Sheep. 599 p.

1884.

July 1. House reports, first session Forty-seventh Congress, vol. 6, Nos. 1618 to 1811, inclusive. 8vo. Sheep. About 1,000 p.

House miscellaneous, second session Forty-seventh Congress, vol. 7. American Ephemeris and Nautical Almanac, 1886. 8vo. Sheep. 525 p.

July 10. Executive documents, second session Forty-seventh Congress, 1882–'83, vol. 14, No. 1, Plate 6; and No. 8 to 34, inclusive. 8vo. Sheep. About 1,000 p.

House miscellaneous, first session Forty-seventh Congress, 1881–'82, vol. 17. 8vo. Sheep. 422 p.

July 18. Executive documents, first session Forty-seventh Congress, 1881–'82, vol. 18, Nos. 13 to 19. 8vo. Sheep. About 1,500 p.

Aug. 7. Executive documents, first session Forty-seventh Congress, 1881–'82, vol, 25, No. 226. Offers for carrying the mails. 8vo. Sheep. P. xxvii–2,006 = 2,033 p.

Aug. 18. Executive documents, first session Forty-seventh Congress, 1881–'82, vol. 7. Signal Office, No. 1. Part 3, vol. 4. 8vo. Sheep. Maps 21. 1,296 p.

Aug. 29. House miscellaneous, second session Forty-seventh Congress, 1882–'83, vol. 13, part 5. Tenth census of United States, vol. 5. Cotton, part 1. 4to. Sheep, p. 600.

Sept. 18. House miscellaneous, second session Forty-seventh Congress, 1882–'83, vol. 13, part 3. Tenth census United States, vol. 3. Agriculture, 17 maps, 6 plates. 4to. Sheep. 1149 p.

House executive documents, first session Forty-seventh Congress, 1881–'82, vol. 10. Indian, &c. No. 1, part 5, vol. 2. 8vo. Sheep. 1132 p.

Executive documents, second session Forty-seventh Congress, 1882–'83, vol. 1. Foreign Relations. No. 1, part 1. 8vo. Sheep, 547 p.

Oct. 24. House miscellaneous, second session Forty-seventh Congress, 1882–'83, vol. 13, part 9. Tenth census of United States. Manufactures, vol. 2, 10 maps, 13 plates. 4to. Sheep. 1198 p.

House miscellaneous, second session Forty-seventh Congress, 1882–'83, vol. 16, Land Laws and Digest of late decisions. 8vo. Sheep. 149 p.

25. Executive documents, second session Forty-seventh Congress, 1882–'83, vol. 3. Engineers, No. 1, part 2, vol. 2, part 1. 8vo. Sheep. 1084 p.

30. Executive documents, second session Forty-seventh Congress, 1882–'83, vol. 19. Nos. 35 to 72, inclusive, except No. 71. Plates 70. 8vo. Sheep. 721 p.

Dec. 30. House miscellaneous, second session Forty-seventh Congress, 1882–'83, vol. 13, No. 42, part 8. Maps 18, plates 101. 4to. Sheep. 1111 p.

United States Senate.

Jan. 10. Senate documents, second session Forty-seventh Congress, No. 84, part 1, vol. 5, 1882–'83. 8vo. Sheep. 711 p.

23. Senate documents, second session Forty-seventh Congress, No. 84, part 2, vol. 5, 1882–'83. 8vo. Sheep. 919 p.

Senate documents, second session Forty-seventh Congress, No. 84, part 3, vol. 5, 1882–'83. 8vo. Sheep. 817 p.

Senate documents, second session Forty-seventh Congress, No. 84, part 4, vol. 5, 1882–'83. 8vo. Sheep. 860 p.

Senate documents, second session Forty-seventh Congress, No. 84, part 5, vol. 5, 1882–'83. 8vo. Sheep. 644 p.

Standing rules for conducting business in the Senate of the United States. Reported by the Committee on Rules, January, 1884. 8vo. Paper. 43 p.

1884.

Jan. 30. Same, with amendments to March 24, 1884. 8vo. Paper. 43 p.

Rules for the regulation of the Senate wing of the United States Capitol adopted by the Committee on Rules, March 15, 1884. 8vo. Paper. 9 p.

Senate reports, vol. 1, 1882-'83, second session Forty-seventh Congress. Nos. 879-980, inclusive. 8to. Sheep.

Senate miscellaneous, second session Forty-seventh Congress, vol. 3, 1883. No. 32. Eulogy Senator Hill. 4to. Sheep.

July 1. Senate documents, third session Forty-sixth Congress, United States Coast and Geodetic Survey, 1880. 4to. Sheep. 83 folded maps. 419 p.

Senate miscellaneous, third session Forty-sixth Congress and special session Forty-seventh Congress. Fish and Fisheries, vol. 3, 1880-'81. 8vo. Sheep. 1060 p.

Special session, convened Oct. 10, 1881, and the first session Forty-seventh Congress, vol. 1, 1881-'82. 8vo. Paper. 1000 p.

INTERIOR DEPARTMENT.

Oct. 28. Register of the Department of the Interior, containing a list of persons employed in the Department, appointed by the President and by the Secretary of the Interior, corrected to October 1, 1884. 8vo. Paper. 171 p.

Office of Commissioner of Railroads.

July 28 Report of Commissioner of Railroads on the Affairs of the Union Pacific Railway Company, June 17, 1884. 8vo. Paper. 15 p.

Bureau of Education.

Jan. 10. The Bufalini Prize. 8vo. Paper. 5 p.

23. Education in Italy and Greece, 1883. 8vo. Paper. 8 p.

Mar. 25. Circular of information of the Bureau of Education, No. 4, 1883. 8vo. Paper. 82 p.

June 30. Circulars of information, No. 4 of 1884. Meeting of the International Prison Congress at Rome, October, 1884. 8vo. Sheep. 11 p.

30. Circulars of information, No. 3 of 1884. Illiteracy in the United States, by Chester Warren, M. D.; National Education, by J. L. M. Curry, LL. D. 8vo. Paper. 99 p.

Preliminary circular respecting the exhibition of education at the World's Industrial and Cotton Centennial Exposition. 8vo. Paper. 11 p.

Report of the Director of the American School of Classical Studies at Athens, 1882-'83 8vo. Paper. 13 p.

July 1. Circulars of information of the Bureau of Education, No. 2, 1884. The Teaching, Practice, and Literature of Shorthand, by Julius Ensign Rockwill, stenographer. 8vo. Paper. 70 p.

Sept. 4. Articles exhibited in the Southern Exhibition of 1884 at Louisville, Ky., from the museum of the U. S. Bureau of Education. 8vo. Paper. 7 p.

8. Circulars of information, No. 5, 1884. Suggestions respecting the educational exhibit at the World's Industrial and Cotton Centennial Exposition. 8vo. Paper. 28 p.

18. Circulars of information, No. 4, 1884. Proceedings of the Department of Superintendence of the National Association, at Washington, February 12-14, 1884. 8vo. Paper. 176 p.

General Land Office.

1884.

Mar. 28. Letter from the Commissioner of the General Land Office to the Secretary of the Interior, January 8, 1884, in relation to the excess of indemnity land certified to the State of Kansas for the benefit of the Atchison, Topeka and Santa Fé Railroad. 8vo. 18 p.

June 30. Circular from General Land Office, showing the manner of proceeding to obtain title to public lands under the pre-emption, homestead, and other laws, issued March 1, 1884. 8vo. Paper. 110 p.

Dec. 6. United States mining laws and regulations thereunder. Circular of October 31, 1881, including circulars of April 27, 1880, September 23, 1880, and later circulars. 8vo. Paper. 41 p.

Indian Office.

June 30. Laws of the United States relating to Indian affairs. 3d edition. 8vo. Paper. 431 p.

Dec. 19. Regulations of the Indian Department, with appendix containing the forms used. Revised by the Indian Bureau. 8vo. Paper. 270 p.

Pension Office.

Mar. 28. Annual report of the Commissioner of Pensions to the Secretary of Interior for the year ending June 30, 1882. 8vo. Paper. 205 p.

Annual report for June 30, 1883. Paper. 8vo. 99 p.

A treatise on the practice of the Pension Bureau, governing the adjudication of Army and Navy pensions, being the unwritten practice formulated. By Calvin B. Walker. 129 pages. 8vo. Board. 129 p.

Aug. 11. Regulations for the recognition of attorneys and agents in claims pending before the Pension Office. Paper. 2vo. 8 p.

21. Instructions to examining surgeons for pensions. 1884. 8vo. Paper. 19 p.

Nov. 1. Roster of examining surgeons appointed under authority of the Commissioner of Pensions, September, 1884. 8vo. Paper. 145 p.

United States Patent Office.

Jan. 10. Catalogue of books in Law Library of the United States Patent Office, 1883. 8vo. Paper. 62 p.

Description and valuation of that portion of the Omaha Indian Reservation in Nebraska lying west of the Sioux City and Nebraska Railroad right of way. 4to. Paper. 20 p.

Ex parte William Long. Appeal from the principal examiner decision of the Commissioner. 8vo. Paper. 25 p.

Subject matter index of patents for invention. France, 1791–1876. 4to. Cloth. 934 p.

June 30. Rules of practice. Revised March 1, 1884. 8vo. Paper. 93 p.

Reports of the examiners, showing the condition of the respective divisions March, 1884. 8vo. Paper. 28 p.

Sept. 12. Rules of practice in the United States Patent Office. Revised August 12, 1884. 8vo. Paper. 94 p.

Nov. 13. In the United States Patent Office. The speaking telephone interferences, Decisions of the examiners-in-chief, cases A, B, C, D, E, F, G, H, I, J, and No. 1. 4to. Paper. 47 p.

United States National Museum.

June 30. Bulletin No. 19, Nomenclator Zoologicus, by Samuel H. Scudder. 8vo, Paper. 340 p.

1884.

June 30. Bulletin No. 20, the published writings of Spencer Fullerton Baird, 1843–1882, by George Brown Goode. 8vo. Paper. 377 p.

July 21. Bulletin No. 25, Contributions to the Natural History of the Bermudas. Vol. 1. 1884. 8vo. Paper. 353 p.

DEPARTMENT OF JUSTICE.

Mar. 28. Annual Report of the Attorney General of the United States for the fiscal year ending June 30—

1873.	8vo.	Board.	93 p.	1880.	8vo.	Board.	113 p.
1874.	8vo.	Board.	85 p.	1881.	8vo.	Board.	128 p.
1878.	8vo.	Board.	89 p.	1882.	8vo.	Board.	131 p.
1879.	8vo.	Board.	91 p.	1883.	8vo.	Board.	171 p.

Register of the Department of Justice and the judicial officers of the United States, including instructions to marshals, district attorneys, and clerks of the United States courts, sixth edition, compiled by authority of the Attorney-General, corrected to July 1, 1883. 8vo. Paper. 230 p.

Report of the general agent of the Department of Justice to the Attorney-General, 1882–'83. 8vo. Paper. 11 p.

Official opinions of the Attorney-General of the United States, advising the President and heads of departments in relation to their official duties and expounding the Constitution, treaties with foreign Governments and with Indian tribes, and the public laws of the country, edited by A. J. Bentley—

Vol. 13.	8vo.	Sheep.	644 p.	Vol. 15.	8vo.	Sheep.	743 p.
Vol. 14.	8vo.	Sheep.	755 p.	Vol. 16.	8vo.	Sheep.	770 p.

July 21. Supreme Court of the United States, proceedings in, on the death of Jeremiah Black. 4to. Paper. 13 p.

Oct. 10. Compilation of the laws of the United States applicable to the duties of the governor, attorney, judge, clerk, marshal, and commissioners of the District of Alaska, compiled under the direction of the Attorney-General. 8vo. Paper. 60 p.

Dec. 15. Exercises at the ceremony of unveiling the statue of John Marshall, May 10, 1884. 1. Plate. 4to. Board. 92 p.

Dec. 27. Cases decided in the Court of Claims at the term of 1883–'84, with abstracts of decisions of the Supreme Court in appealed cases from October, 1883, to May, 1884. Vol. 19. 8vo. Paper. 808 p.

NAVY DEPARTMENT.

Jan. 10. Regulations governing the admission of candidates into the Naval Academy as Naval Cadets, 1883–'84. 8vo. Paper. 7 p.

Regulations governing the uniform of officers of the United States Navy 1883. Plates. 8vo. Paper. 15 p.

Mar. 22. Register of the commissioned and warrant officers of the Navy of the United States, including officers of the Marine Corps, to January 15, 1884. 8vo. Paper. 214 p.

Aug. 8. Same to August 1, 1884. 8vo. Paper. 75 p.

23. Acts and resolutions relating to the Navy Department and Marine Corps, passed at the first session of the Forty-eighth Congress. 1883–'84. 8vo. Paper. 49 p.

Oct. 17. Report of Secretary of the Navy of 1883. vol. 2. (50 copies—20 cloth, 20 board, and 10 half sheep.) 8vo. 622 p.

18. Report of the Board of Visitors to the United States Naval Academy, June, 1884. 8vo. Paper. 27 p.

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Oct. 30. **Greely Relief Expedition. Reception of Lieut. A. W. Greely, United States Army, and his comrades and of the Arctic Relief Expedition at Portsmouth, N. H., on August 1 and 4, 1884. Account prepared at the request of the Navy Department, by Rev. Wm. A. McGinley of Portsmouth. 8vo. Paper. 58 p.**

Dec. 1. Annual Register of the United States Naval Academy, Annapolis, Md. Thirty-fifth Academic year, 1884-'85. 8vo. Paper. 66 p.

Dec. 15. Navy Yard Commission. Special Report of A. B. Mullett. Civil Commissioner. 8vo. Paper. 11 p.

Hydrographic Office.

Jan. 10. Hydrographic Notices, 1883:
- No. 73. New Zealand—North Island, West Coast. 2 p.
- No. 74. China Sea—Natuna Island. 4 p.
- No. 75. United States—Maine. 2 p.
- No. 76. United States—New York—East River. 1 p.
- No. 77. Indian Archipelago—Celebes—East Coast. 2 p.
- No. 78. Mediterranean—Greece, Santa Maur Island. 1 p.
- No. 79. Brazil—Cape Saint Roque. 1 p.
- No. 80. China Sea—Java Sea. 3 p.
- No. 81. Australia—Gulf of Carpentaria. 10 p.
- No. 82. Korea—West Coast—Prince Imperial Archipelago. 2 p.
- No. 83. Mediterranean—Greece—Gulf Volo. 2 p.
- No. 84. England—British Channel. 2 p.
- No. 85. Indian Ocean. 2 p.
- No. 86. North Atlantic Ocean. 2 p.
- No. 89. New Zealand—Middle Island—Buller River. 2 p.
- No. 90. China Sea, Corea—Approaches to Seoul. 3 p.
- No. 91. Borneo—Northeast Course Nymphe Reef. 2 p.
- No. 92. Indian Ocean—Madagascar. 1 p.
- No. 93. Australia—East Coast—Percy Islands. 1 p.

Jan. 23.
- No. 70. United States—Rhode Island. 1 p.
- No. 71. Mediterranean—Tunis. 2 p.
- No. 87. United States—Delaware. 2 p.
- No. 88. Caribbean Sea—Little Antilles. 1 p.
- No. 189. Sweden—Karings Rock. 8vo. Paper. 2 p.
- No. 201. Sweden—West Coast—Skagerrak. 8vo. Paper. 4 p.

Publications of Hydrographic Office during the quarter ending December 31, 1883. 8vo. Paper. 11 p.

Hydrographic Notices, 1883.
- No. 1. West Coast of Mexico. 1 p.
- No. 2. Atlantic Coast Pilot Division B.

Hydrographic Notices, 1884:
- No. 3. Germany—Hever River. 8vo. Paper. 2 p.
- No. 4. France—Bandol Bay. 8vo. Paper. 2 p.
- No. 5. Canary Islands—Santa Cruz de Teneriffe. 8vo. Paper. 2 p.
- No. 6. Buenos Ayres—Dikes and lights. 8vo. Paper. 3 p.
- No. 7. Friendly Islands—Bank in Tongatabu Harbor. 8vo. Paper. 4 p.
- No. 8. Psau Liang Hai—Shoal. 8vo. Paper. 1 p.
- No. 9. France—Isle de Bas. 8vo. Paper. 3 p.
- No. 10. Java—Light on Merak Island. 8vo. Paper. 2 p.
- No. 11. Daunt Rock light-ship. 8vo. Paper. 3 p.
- No. 12. Black Sea—Fog-signals. 8vo. Paper. 3 p.

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Hydrographic Notices, 1884—Continued.

Jan. 23. No. 13. St. Mazaire—Change of light. 8vo. Paper. 1 p.
No. 14. Java—Light at Cheribon. 8vo. Paper. 2 p.
No. 15. Yangtse River entrance—A shoal. 8vo. Paper. 3 p.
No. 16. Austro-Hungary—Cittanuova. 8vo. Paper. 3 p.
No. 17. England—Outer Dowsing Shoal. 8vo. Paper. 4 p.
No. 18. China Sea Directory—High Lomach Island. 8vo. Paper. 2 p.
No. 19. Montreal—Light discontinued. 8vo. Paper. 1 p.
No. 20. Thames River entrance. 8vo. Paper. 2 p.
No. 21. Spain—Cadiz—Bury. 8vo. Paper. 2 p.
No. 22. Madagascar—Shoal. 8vo. Paper. 2 p.
No. 23. Borneo, northwest coast. 8vo. Paper. 3 p.
No. 24. Austro-Hungary—Light. 8vo. Paper. 2 p.
No. 25. Brazil—Santa Anna Island light. 8vo. Paper. 2 p.
No. 26. Leruka—Lights. 8vo. Paper. 3 p.
No. 27. Boston—Change of lights. 8vo. Paper. 1 p.
No. 28. China Sea—Gulf of Tong-King. 8vo. Paper. 2 p.
No. 29. Pilot regulations. 8vo. Paper. 3 p.
No. 30. France, southern coast—Light. 8vo. Paper. 3 p.
No. 31. Non-resistance of shoal. 8vo. Paper. 2 p.
No. 32. New Jersey—Sandy Hook. 8vo. Paper. 1 p.
No. 33. South Carolina—Charleston. 8vo. Paper. 1 p.
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No. 38. Spencer Gulf—Port Augusta. 8vo. Paper. 2 p.
No. 39. Holyhead Bay—Rocks. 8vo. Paper. 2 p.

June 27. No. 40. Greece—Hydra Island light. 8vo. Paper. 2 p.
No. 41. Bombay—Time-ball. 8vo. Paper. 1 p.
No. 42. Magellan Straits—Landmarks. 8vo. Paper. 2 p.
No. 43. Connecticut—Light-house. 8vo. Paper. 1 p.
No. 44. Algeria—Dellys—Light. 8vo. Paper. 1 p.
No. 45. Madagascar—Autonga—Shoal. 8vo. Paper. 2 p.
No. 46. Gillert Group—Hopper Island. 8vo. Paper. 4 p.
No. 47. Corsica—Vecchio. 8vo. Paper. 1 p.
No. 48. Belgium—Schelde River. 8vo. Paper. 3 p.
No. 49. China Sea—Shoal. 8vo. Paper. 3 p.
No. 50. Ceylon—Columbo light. 8vo. Paper. 2 p.
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No. 61. Iceland—Magnetic observations. 8vo. Paper. 2 p.
No. 62. Cochin China—Pulo Condore. 8vo. Paper. 1 p.
No. 63. Tonquet. 8vo. Paper. 1 p.
No. 64. East coast—Bet-el-Ras shoal—Beacon. 8vo. Paper. 3 p.
No. 65. Gulf of Burglaz—Light at Megalo—Nice. 8vo. Paper. 2 p.

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Hydrographic Notices, 1884—Continued.

June 27. No. 66. Scotland—Burghead light. 8vo. Paper. 3 p.

No. 67. Paumotou Islands. 8vo. Paper. 1 p.

No. 68. Trinidad—Diamond Rock—Bell-buoy. 8vo. Paper. 2 p.

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No. 70. Austro-Hungary—Cape Promontore—Fog-signals. 8vo. Paper. 3 p.

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No. 72. Shelburne harbor—Fog-horn. 8vo. Paper. 1 p.

No. 73. Canton River. 8vo. Paper. 1 p.

No. 74. South Foreland—Experimental lights. 8vo. Paper. 2 p.

No. 75. Sardinia—Sant Antioco Island. 8vo. Paper. 1 p.

No. 76. Carimata Strait—Pulo Kumpal. 8vo. Paper. 7 p.

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No. 81. Grand Bassa—Simken rock. 8vo. 1 p.

No. 82. Encounter Bay—Fort Victor light. 8vo. 3 p.

Fo. 83. France—Cayeux. 8vo. Paper. 1 p.

No. 84. Spain—Port Passages. 8vo. Paper. 3 p.

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No. 89. Piel Harbor. 8vo. Paper. 3 p.

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No. 94. Malta—Shoals off St. Elms point. 8vo. Paper. 1 p.

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No. 112. Carimata Strait—Scharroyd Islands. 8vo. Paper. 2 p.

No. 113. Canada—Lake Huron—Kincardine light. 8vo, Paper. 1 p.

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Hydrographic Notices, 1884—Continued.

June 27. No. 114. Marshall Group—Namorich (Baring) Island. 8vo. Paper.
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No. 164. Canton—Shamien—Light. 8vo. Paper. 1 p.
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Hydrographic Notices, 1884—Continued.

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No. 167. Danger Signals. 8vo. Paper. 2 p.
No. 168. Kertch Strait—Anchorage. 8vo. Paper. 2 p.
No. 169. Italy—Giglio Island—Light. 8vo. Paper. 1 p.
No. 170. Mediterranean—Mersinah—Light. 8vo. Paper. 1 p.
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No. 172. Brazil—San João Island—Light. 8vo. Paper. 1 p.
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June 27. Index to hydrographic notices, 1 to 93. 8vo. Paper. 23 p.
Index to hydrographic notices, 1 to 216. 8vo. Paper. 30 p.

July 1. Catalogue of charts, plans, and sailing directions, July, 1884. 8vo. Paper. 196 p.
Same, North Atlantic Station. 8vo. Paper. 95 p.

10. Notices to mariners, Nos. 189 to 213, inclusive. 8vo. Paper. Total number pages 42.

10. Notices to mariners, Nos. 216 to 227, inclusive. 8vo. Paper. Total number pages 17.

10. Notices to mariners, No. 229. 8vo. Paper. 2 p.

10. Publications of the United States Hydrographic Office during the quarter ending March 30, 1884. 8vo. Paper. 7 p.

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July 10. Notice to mariners, Nos. 185 to 188, inclusive of 1884. 8vo. Paper. Total number pages 8.

28. No. 1, list of lights on the east and west coasts of North and South America, including the West India and Pacific Islands, corrected to July 1, 1884. 8vo. Paper. P. 267, XXIV. 291 p.

30. No. 2, list of lights of south and east coasts of Asia and Africa and the East Indias, including Australia, Tasmania, and New Zealand, corrected to July 1, 1884. 8vo. Paper. P. 169 and XIV. 183 p.

Statement of the Secretary of the Navy in reply to the resolutions of both Houses of Congress for the appointment of committees on ordnance and naval construction, July 12, 1884. 8vo. Paper. 12 p.

Aug. 4. No. 3, list of lights of the west coast of Africa, and the Mediterranean Sea, including the Adriatic, the Black Sea, and the Sea of Azof, corrected to July 1, 1884, at the United States Hydrographic Office. 8vo. Paper P. 269, XXII. 291 p.

4. No. 4, list of lights of the Atlantic coast of Europe and the southern shores of the English Channel and North Sea. 8vo. Paper. P. 175, XXII. 197 p.

5. Notice to mariners, Nos. 228 to 284 (except No. 229). 8vo. Paper. Total pages 93.

8. No. 5, list of lights of the North Baltic and White Seas, corrected to July 1, 1884. 8vo. Paper. P. 157, XXII. 169 p.

8. No. 6, list of lights of the British Islands, corrected to July 1, 1884. 8vo. Paper. P. 149, X. 159 p.

14. Publications of the United States Hydrographic Office during the quarter ending June 30, 1884. 8vo. Paper. 9 p.

Sept. 3. Catalogue of charts, plans, and sailing directions issued to vessels on the European Station. 8vo. Paper. 120 p.

3. Notice to mariners, No. 206, of 1884. 8vo. Paper. 11 p.

5. Notice to mariners, No. 285, of 1884. 8vo. Paper. 2 p.

5. Notice to mariners, Nos. 287 to 321, of 1884. 8vo. Paper. Total number pages 66.

22. Newfoundland and Labrador, No. 73; the coast and banks of Newfoundland and the coast of Labrador, &c., compiled by Lieut. W. W. Gillpatrick and Ensign John Gibson, United States Navy. 8vo. Paper. 615 p.

Oct. 3. Notice to mariners, Nos. 322 to 363, inclusive, of 1884. 8vo. Paper. Total number pages 83.

Nov. 13. Publications of Hydrographic Office during the quarter ending September 30, 1884. 8vo. Paper. 8 p.

27. Catalogue of charts, plans, and sailing directions issued to vessels on the South Atlantic Station. 8vo. Paper. 56 p.

Nautical Almanac.

Mar. 28. The American Ephemeris and Nautical Almanac for 1884. Second edition, 4 tables. 4to. Paper. 496 p.

Nov. 16. The American Ephemeris and Nautical Almanac for 1885. Second edition, 2 plates. 4to. Paper. 522 p.

Bureau of Medicine and Surgery.

Mar. 25. Hygienic and medical reports, by medical officers of the United States Navy. Prepared for publication under the direction of the Surgeon-General of the Navy, by Joseph B. Parker, A. M., M. D., Surgeon United States Navy, assisted by the Bureau of Medicine and Surgery. 8 vo. Sheep. 1070 p.

1884.

Mar. 25. Sanitary and statistical report of the Surgeon-General of the Navy for the year 1879. 8vo. Sheep. 361 p.

Same for the year 1880. 8vo. Sheep. 469 p.

Same for the year 1881. 8vo. Sheep. 684 p.

Bureau of Equipment and Recruiting.

Aug. 23. Regulations for the enlistment, government and instruction of naval apprentices, as authorized by the circular of the Navy Department, dated January 1, 1884. 8vo. Paper. 29 p.

Bureau of Navigation.

Jan. 23. List of lights of the East and West coasts of North and South America (except the United States), corrected to October 9, 1883. 8vo. Paper. 175 p.

Professional papers, No. 13, magnetism; its original principles and special application to ships and compasses, 1883. 8vo. Paper. 280 p.

Mar. 22. The American Practical Navigator, being an epitome of navigation and nautical astronomy, by Nathaniel Bowditch, LL. D. 4to. Paper. 647 p.

June 27. Information from Abroad, report on the exhibits at the Crystal Palace Electrical Exhibition, 1882, by Ensign Frank J. Sprague, United States Navy. 8vo. Paper. 169 p.

Sept. 4. General Information, series No. 111, Examples, Conclusions, and Maxims of Modern Naval Tactics. 26 plates. 8vo. Paper. 149 p.

15. Naval Professional Papers, No. 16; papers and discussions on engines, boilers and torpedo boats. 8vo. Paper. 219 p.

Oct. 16. Astronomical and meteorological observations made during the year 1880 at the United States Naval Observatory. 4to. Cloth. 5 plates. P. LXXIX and 267 p.

Dec. 20. The International Code of Signals for the use of all Nations. 4 plates. 8vo. Paper. 256 p.

Bureau of Steam Engineering.

Mar. 22. Annual report of the Chief of the Bureau of Steam Engineering for 1883. 8vo. Paper. 63 p.

POST-OFFICE DEPARTMENT.

Jan. 30. Street Directory of the principal cities of the United States. Second edition. 8vo. Paper. 43 p.

Oct. 4. Letter carriers of the Saint Louis post-office—laws and regulations concerning letter-carriers and their duties. Saint Louis, October, 1884. 8vo. Paper. 16 p.

STATE DEPARTMENT.

Mar. 28. Reports from the consuls of the United States on the commerce, manufactures, &c., of their consular districts, No. 36, December, 1883. 8vo. Paper. 397 p.

Aug. 8. Commercial relations between United States and Central and South America. 8vo. Paper. 3 p.

Oct. 17. Register of the Department of State corrected to October 1, 1884. 8vo. Paper. 118 p.

SUPREME COURT.

1884.

Jan. 23. Rules of the Supreme Court of the United States, adopted January 7, 1884. 8vo. Paper. 24 p.

June 30. Record of the Star Route trials. Second trial. 4 volumes. 8vo. Sheep.

TREASURY DEPARTMENT.

Mar. 25. Annual report of the Treasurer of the United States to the Secretary of the Treasury for the fiscal year ending June 30, 1883. 8vo. Paper. 59 p.

Sixth annual report of the Treasurer of the United States on the sinking fund and funded debt of the District of Columbia. 8vo. Paper. 40 p.

July 30. Steamboat inspection service, steamboat inspector's manual laws governing the steamboat inspection service, Revised Statutes of the United States as amended at the first session of the Forty-seventh Congress, 1881–'82, to which are added the revised rules and regulations of the Board of Supervising Inspectors as amended January, 1882–'83, together with the various decisions of the Treasury Department. Third edition revised, 1882–'83–'84. 8vo. Paper. 222 p.

Nov. 6. Instructions to custodians of public buildings under the control of the Treasury Department, October 10, 1884. 8vo. Paper. 20 p.

United States Coast and Geodetic Survey.

Jan. 23. Atlantic Local Coast Pilot, sub-division 15, Delaware Bay and tributaries, 1st edition, appendix XII. 4vo. Paper. 139 p.

Mar. 25. Summary Report of the progress of the United States Coast and Geodetic Survey, for the fiscal year ending with June, 1883. 8vo. Paper. 21 p.

June 30. Tide Tables, Pacific Coast, 1885. 8vo. Paper. 66 p.

June 30. Tide Tables, Atlantic Coast, 1885. 8vo. Paper. 136 p.

Aug. 25. Pacific Coast Pilot Alaska. Part 1. 8vo. Paper. 333 p.

Aug. 29. Methods and Results Field Catalogue of Time and Circumpolar Stars for 1885. Appendix No. 18. Report for 1883. 8vo. Paper. 91 p.

Sept. 3. Methods and Results Field Catalogue of Time and Circumpolar Stars for 1885. Appendix No. 18. Report for 1883. 8vo. Paper. 91 p.

Oct. 10. Methods and results, Report of a Conference on Gravity Determinations. Appendix No. 22. Report for 1882. 4vo. Paper. 13 p.

Oct. 17. Catalogue of Charts 1884, J. E. Hilgard, Superintendent. 4vo. Paper. 68 p.

Dec. 6. Summary Report of the progress of the United States Coast Survey for the fiscal year ending with June, 1883. 8vo. Paper. 20 p.

Dec. 27. Short descriptions of articles forming the Coast and Geodetic Survey exhibit at the Cotton Centennial Exposition, New Orleans, La., 1884–'85. 8vo. Paper. 25 p.

Comptroller of the Currency.

June 30. Instructions and suggestions of the Comptroller of the Currency in regard to the organization, extension and management of National Banks. 8vo. Paper. 39 p.

Inspector-General of Steamboats.

Dec. 19. Annual Report of the Supervising Inspector-General of Steamboats to the Secretary of the Treasury, for the fiscal year ended June 30, 1884. 8vo. Paper. 23 p.

Internal Revenue.

1884.

Mar. 25. Series 7, No. 11, Revised United States Internal Revenue Gaugers Manual, embracing regulations and instructions, and tables prescribed by the Commissioner of Internal Revenue, by virtue of Sec. 3249, United States Revised Statutes. 1 plate. 8vo. Paper. 64 p.

United States Life-Saving Service.

1884.

Oct. 8. Annual Report of the operations of the United States Life-Saving Service for the fiscal year ending June 30, 1883. 8vo. Paper. 519 p.

Light-House Board.

June 30. List of lights in the waters and on the shores and banks of the Northern Lakes and Rivers of the United States, and also of the Canadian lights in these waters, corrected to January, 1884. 4to. Paper. 53 p.

July 1. List of beacons, buoys, stakes, and other day-marks in the first light-house district, embracing the sea-coasts, bays, harbors, and rivers from the north-east boundary of the United States to Hampton Harbor, New Hampshire, corrected to May 1, 1884. 4to. Paper. 42 p.

Oct. 11. List of beacons, buoys, stakes, and other day-marks in the fourth light-house district, embraced in the sea-coasts, bays, harbors, and rivers from Squam Inlet, New Jersey, to Metomkin Inlet, Virginia, corrected to September 1, 1884. 4to. Paper. 26 p.

List of beacons, buoys, and stakes in the twelfth light-house district, embracing the sea-coast and bays of California, corrected to October 1, 1884. 4to. Paper. 14 p.

Oct. 16. List of beacons, buoys, and stakes in the second light-house district, corrected to August 1, 1884. 4to. Paper. 61 p.

Oct. 25. List of beacons, buoys, and stakes in the fifth light-house district, corrected to August 1, 1884. 4to. Paper. 71 p.

Dec. 4. List of beacons, buoys, and stakes in the third light-house district, embracing the sea-coasts, harbors, and rivers from Gooseberry Point, Massachusetts, southward along the coast as far as Squaw Inlet, New Jersey, and including Lake Champlain and Lake Memphremagog, corrected to October 1, 1884. 4to. Paper. 77 p.

Dec. 15. List of beacons, buoys, and stakes in the seventh light-house district, embracing the coast of Florida from Jupiter Inlet to Egmont Key, Tampa Bay, and Cedar Keys, inclusive; also Saint Mark's, Saint George's Sound, Apalachicola, Saint Andrew's, and Pensacola Bays, corrected to October 1, 1884. 4to. Paper. 30 p.

Bureau of Statistics.

June 30. The operations of the tariff act of March 2, 1883, for the six months ended December 31, 1883, April 21, 1884. 8vo. Sheep. 70 p.

Reciprocity of transportation facilities between the United States and the Dominion of Canada and the Canadian Pacific Railroad. 8vo. Paper. 11 p.

Jan. 10. Summary statement of imports and exports of the United States for the month ending—

October 31, 1883. 4to. Paper. 14 p.
November 30, 1883. 4to. Paper. 14 p.
December 31, 1883. 4to. Paper. 17 p.

June 10. January 31, 1884. 4to. Paper. 18 p.
February 29, 1884. 4to. Paper. 14 p.
March 31, 1884. 4to. Paper. 14 p.

1884.

June 10. Quarterly report relative to imports, exports, immigration, and navigation of the United States for the three months ended—

Jan. 10. September 30, 1883. 8vo. Paper. 133 p.

Mar. 25. June 30, 1883. 8vo. Paper.

June 30. December 31, 1883. 8vo. Paper. 135 p.

July 1. Document No. 588 (No. 10, April, 1883–'84). Summary statement of the imports and exports of the United States for the month ended April 30, 1884, and for the ten months ended the same, compared with the corresponding periods of 1883. 4to. Paper. 14 p.

July 10. No. 3, 1883–'84. Quarterly report of the Chief of the Bureau of Statistics, Treasury Department, relative to the imports, exports, immigration, and navigation of the United States for the three months ended March 31, 1884; also containing other statistics relative to the trade and industry of the country. 8vo. Paper. 396 p.

Oct. 17. Quarterly report of the Chief of the Bureau of Statistics, relative to the imports, exports, immigration, and navigation of the United States for the three months ending June 30, 1884; also containing other statistics relative to the trade and industry of the country. 8vo. Paper. 573 p.

Nov. 28. Index to quarterly reports of the Chief of the Bureau of Statistics, showing the imports and exports of the United States for the four quarters of the fiscal year ended June 30, 1884, and for the corresponding quarters of the year immediately preceding; also embracing other statistical tables relative to the trade of this and foreign countries for various periods. 8vo. Paper. 12 p.

WAR DEPARTMENT.

Mar. 22. Official table of distances for the guidance of disbursing officers of the Army charged with the payment of money allowances for travel. 8vo. Paper. 189 pp.

Official Army Register for January, 1884. 8vo. Paper. 390 p.

Mar. 28. Report of board of officers to consider an expedition for the relief of Lieutenant Greely and party. 8vo. Paper. 192 p.

June 30. Alphabetical list of additions made from June, 1882. 4to. Paper. 39 p.

Aug. 12. Army Paymaster's Manual, for the information of the officers of the Pay Department of the United States Army. Revised to include June 30, 1884. 8vo. Paper. 78 p.

Adjutant-General's Office.

Jan. 10. General orders, 1883:

No. 83. 8vo. Paper. 1 p.
No. 84. 8vo. Paper. 7 p.
No. 85. 8vo. Paper. 3 p.
No. 90. 8vo. Paper. 1 p.
No. 91. 8vo. Paper. 1 p.
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Jan. 23. No. 86. 8vo. Paper. 1 p.
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No. 96. 8vo. Paper. 1 p.
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No. 100. 8vo. Paper. 18 p.

Circular No. 11, 1883. 8vo. Paper. 3 p.

1884.

General court-martial orders, 1883:

Jan. 23. No. 53. 8vo. Paper. 1 p. No. 59. 8vo. Paper. 2 p.

No. 54. 8vo. Paper. 6 p. No. 60. 8vo. Paper. 5 p.

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Circular No. 10, 1883. 8vo. Paper. 2 p.

Index of general court-martial orders, 1884. 8vo. Paper. 5 p.

Mar. 22. General court-martial orders, 1883:

No. 1. 8vo. Paper. 9 p.

No. 2. 8vo. Paper. 8 p.

No. 3. 8vo. Paper. 2 p.

No. 4. 8vo. Paper. 2 p.

Circular No. 12, 1883. 8vo. Paper. 2 p.

General orders, 1884:

No. 1. 8vo. Paper. 2 p. No. 3. 8vo. Paper. 1 p.

No. 2. 8vo. Paper. 1 p. No. 4. 8vo. Paper. 1 p.

June 30. Circulars for 1884:

No. 1, February 18, 1884. 8vo. Paper. 3 p.

No. 2, March 14, 1884. 8vo. Paper. 3 p.

No. 3, April 14, 1884. 8vo. Paper. 1 p.

No. 4, May 14, 1884. 8vo. Paper. 3 p.

General orders, index to general orders for 1883.

General orders for 1884, Nos. 5–39, 41, 43, 44, 46, 47. 8vo. Paper.

General court-martial orders, index for 1883, and No. 63, orders for 1884, Nos. 5–25. 8vo. Paper.

July 5. Proceedings of a court of inquiry convened the 5th May, 1884, to examine into the accusations against Brig. Gen. David G. Swaim. 8vo. Paper. 308 p.

July 1. General court-martial orders No. 27, January 4, 1884. 8vo. Paper. 6 p.

Circular, June 5, 1884. 8vo. Paper. 1 p.

Circular No. 5, June 10, 1884. 8vo. Paper. 2 p.

General court-martial orders No. 26. 8vo. Paper. 4 p.

July 10. General orders, 1884:

No. 40. 8vo. Paper. 2 p.

No. 42. 8vo. Paper. 1 p.

No. 45. 8vo. Paper. 1 p.

Nos. 48 to 54, inclusive. 8vo. Paper. 10 p.

July 21. No. 64. 8vo. Paper. 12 p.

General court-martial orders, 1884:

No. 28, July 17, 1884. 8vo. Paper. 4 p.

No. 29, July 28, 1884. 8vo. Paper. 2 p.

Aug. 8. General orders, 1884:

No. 52. 8vo. Paper. 1 table. 8 p.

No. 73, July 18, 1884. 8vo. Paper. 8 p.

Aug. 13. No. 60, June 30, 1884. 8vo. Paper. 1 p.

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1884.

Aug. 14. No. 61, July 2, 1884. 8vo. Paper. 1 p.
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Aug. 20. Circular No. 6, July 8, 1884. 8vo. Paper. 2 p.

Aug. 21. Ordnance notes, No. 355. A peculiar phase of metallic behavior, by Capt. O. E. Michaelis. 2 plates. 8vo. Paper. 5 p.

Aug. 23. The soldiers' hand-book for the use of enlisted men of the Army, by N. Hershler. 8vo. Paper. 62 p.

Sept. 3. General court-martial orders, 1884:
No. 30, July 9, 1884. 8vo. Paper. 4 p.
No. 31, July 25, 1884. 8vo. Paper. 3 p.
No. 32, August 2, 1884. 8vo. Paper. 7 p.

General orders, 1884:
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Oct. 24. An epitome of Tripler's manual for the examination of recuits. 8vo. Paper. 51 p.

Oct. 9. General orders, 1884:
No. 85, August 2, 1884. 8vo. Paper. 1 p.
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1884.

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1884.

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Burlington, Iowa, during the month of October, 1879. Illustrated by one sketch and 41 plates. By Maj. Alexander Mackenzie. 8vo. Paper. 38 p.

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Ordnance Office.

Ordnance notes:

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No. 350, May 29, 1884. 5 p.
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July 21. No. 348, May 19, 1884. 4to. Paper. 9 p.

1884.

Ordnance notes—Continued.

July 1. No. 345, April 29, 1884. Report on transcontinental railways, 1883. By Col. O. M. Poe, U. S. Engineers, A. D. C., and brevet brigadier-general. 1 map. 4to. Paper. 58 p.

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No. 347, May 15, 1884. Military rifles. Communicated by the director of artillery. 4to. Paper. 4 pages.

Aug. 4. Ordnance Memoranda No. 24. Management of 8-inch muzzle-loading rifles and carriages. Table of ranges, descriptive plates, &c. 8vo. Paper. 10 plates. 11 p.

Ordnance notes:

Aug. 13. No. 353, June 1, 1884. United States Life-Saving Service. 8vo. Paper. 12 p.

Aug. 16. No. 352, June 14, 1884. Field artillery fire. 8vo. Paper. 13 p.

Aug. 25. No. 357. Electricity applied to explosive purposes; June 30, 1884. 8vo. Paper. 26 p.

Sept. 4. No. 356, June 28, 1884. Electrical units of measurement. 8vo. Paper. 17 p.

Sept. 13. Notes on the Construction of Ordnance, No. 29. Manufacture of sabots for muzzle-loading projectiles. By Lieut. R. Birne, jr. 1 plate. 8vo. Paper. 5 p.

Ordnance notes:

Oct. 2. No. 351. The manufacture of steel and its application to military purposes. By Capt. G. Mackinlay, R. A. 8vo. Paper. 16 p.

No. 354. Meteorological investigations. By Capt. O. E. Michaelis, Ordnance Department. 3 plates. 8vo. Paper. 5 p.

Notes on the construction of ordnance:

Oct. 11. No. 27, June 10, 1884. Position and form of bands for projectiles. By Capt. M. P. Breger, French Marine Artillery. 4to. Paper. 32 p.

Dec. 1. No. 30, July 1, 1884. The adoption of standard forms of test pieces for bars and plates. By William Hackney. 4to. Paper. 62 p.

Dec. 26. Vol. 1. 4to. Paper. 12 p.

United States Signal Office.

June 30. Professional Papers, No. XIII. Temperature of the atmosphere and earth's surface. By Prof. William. Ferrell. 4to. Paper. 69 p.

Surgeon-General's Office.

Sept. 29. Index-catalogue of the library of the Surgeon-General's Office. Authors and subjects. Vol. V. Flaccus–Hearth. 4to. Paper. 1,055 p.

REPORT ON EXPLORATIONS AND COLLECTIONS IN THE QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA.

By JAMES G. SWAN.

In 1873 I wrote a memoir on the Haidah Indians, of Queen Charlotte Islands, which was published in the Smithsonian Contributions to Knowledge (No. 267), January, 1874. In the *advertisement* the late Professor Henry says that, "under the head of ethnology, it raises some questions which seem of great significance, and which it is hoped will lead to further investigations." It was not, however, till 1883 that an arrangement was effected, when, early in that year, I was sent by Professor Baird to that interesting group of islands lying in the North Pacific Ocean, off the coast of British Columbia, between lat. 51° 30′ and 54° 20′ north, to make collections and obtain useful information for the United States Fish Commission, the National Museum, and the Bureau of Ethnology.

On the 29th day of May, 1883, I left Port Townsend, Wash., for Victoria, B. C., to make my arrangements for the cruise, by purchasing all necessary stores and outfits, and securing a credit with the Hudson Bay Company to make purchases and draw orders on their traders at Fort Simpson, B. C., and at Masset, on Graham Island, the largest of the Queen Charlotte group. I also made a similar arrangement with the Skidegate Oil Company to give orders on their store at their oil works, near Skidegate village, B. C. This was to enable me better to trade with Indians for the procuring of specimens of their manufactures, and to avoid the trouble and risk of carrying coin with me to those islands, and to enable me to keep an account of my expenditures in a more satisfactory manner. Having completed my arrangements, I next secured the services of an assistant and interpreter, a young Haidah Indian, a native of the Klue or Cumshewa district on the eastern coast of Moresby Island, the second largest of the Queen Charlotte Islands. This Indian, whose name is *Johnny Kit Elseva*, I had personally known for some time as one of the most intelligent, faithful, and reliable natives I ever have seen. To his qualifications as a cook and general servant he added those of an interpreter; his knowledge of English, which he speaks fluently, enabling him to understand me fully at all times. He is also a working jeweler, skilled in making silver bracelets, ear-rings, and charms, and a good carver in wood and stone. He is also an artist, and has drawn for me in India ink a series of mythological sketches illustrative of the folk-lore of his tribe, and is still at work in finishing

other sketches, which, when completed and fully described by me, will be forwarded for the use of the Smithsonian Institution.

As the communication with Queen Charlotte Islands is very uncertain I was obliged to wait for the steamer "Otter," which for many years has made semi-annual voyages to the islands, going in the spring with supplies for the Hudson Bay Company trading-post at Masset, and with goods for the oil company at Skidegate, and returning in October to take away the furs, fish, and oil that have been collected during the season.

From some cause of delay the "Otter" did not leave Victoria until Monday, June 18, when we made a start at noon for Masset via all the trading stations and canneries on the route. I did not object to this, as I was thereby enabled to see many places where I expected to procure specimens, without additional cost for passage. As the detail of a sea voyage would be unnecessary here, I will omit all mention of it except of the places where we stopped.

The next day, June 19, we arrived at Alert Bay, on Cormorant Island, the trading-post and cannery of Mr. Wesley Hudson, who has been there a number of years, and takes an interest in scientific matters, and is considered a reliable man in all his statements regarding fisheries, seals, and other fur-bearing animals, and in Indian lore. I shall refer to this gentleman in my general report.

At 11.45 p. m. we left Alert Bay and ran down Johnson's Strait to Queen Charlotte Sound, and at 1 p. m. on the 20th we arrived at the canneries of Shotbolt & Co., at the head of River's Inlet, where we discharged some freight, and left at 2.30 p. m. In this inlet, besides Shotbolt's canneries, are a saw-mill and canning establishment of Messrs. Saunders and Warren, of Victoria, but I did not visit them, as the steamer remained so short a time.

After leaving River's Inlet we ran up Fitzhugh Sound to the Hudson Bay Company's trading-post of Bella Bella, where we arrived June 21 at 1.30 a. m., and left at 2. a. m. for the mouth of the Skeena River, where there is another cannery, at a place called Port Essington, where we arrived at midnight; but I did not go ashore, as we shortly left for Metlakatla, where we arrived at 6.30 a. m. on Friday the 22d.

Shortly after our arrival Bishop Ridley, the bishop of the diocese, came on board and kindly invited me to go ashore with him, which I did, and was introduced by him to Rev. Mr. Collinson, one of the missionaries, who has a fine collection of fossils and Indian curiosities, which he kindly showed me, but as I had but a short time to remain on shore I made a hurried visit, which I would gladly have prolonged, and then went to the residence of the Rev. Mr. Duncan, the founder of the Metlakatla mission, and the teacher and preacher to the Indians of the Tsimsean tribe, who have a settlement at Metlakatla.

I was very cordially received by Mr. Duncan, who showed me some blankets and shawls made by the mission Indians, and then took me to

his cannery, where some fifty Indians, men and women, were engaged canning salmon. Everything was scrupulously neat and clean, and the whole work done with a precision and exactness which showed that Indians can be taught to do such kind of work, and, when taught, are as capable as a majority of white men, and are far preferable to Chinese. Mr. Duncan next wished me to visit his church, which I desired very much to do, but just then the whistle of the old steamer Otter gave the signal for departure, and, escorted by Mr. Duncan, I returned on board, and at 8.15 a. m. we left for the Hudson Bay Company's post at Fort Simpson, where we arrived at 12 o'clock noon.

Fort Simpson is situated on the mainland but a few miles south of the boundary between British Columbia and Alaska. It is one of the principal trading-posts of the company, and is under charge of Mr. R. H. Hall, from whom I purchased a quantity of Indian manufactures in carved stone, to be sent by him to Victoria for me. I also saw Rev. Thomas Crosby, Wesleyan missionary, from whom I purchased several articles made by Tsimsean Indians, and then went with him to visit his church and school. I found a marked improvement in the appearance of Fort Simpson since I visited it seven years ago in the U. S. S. "Wolcott." The old unsightly Indian houses of former days had been removed, and a pretty village of neat cottages surrounds the fine church, and gives evidence of the skill and taste of the Indians, when encouraged by intelligent sympathy, to emulate the dwellings of white men. The general effect of the village, when viewed from the anchorage, is very pleasing, and would be creditable to any of our frontier towns.

At 1.30 P. M. we left Fort Simpson for Fort Wrangel, Alaska, where we arrived the next morning (Saturday, 23d) at 8 o'clock.

At Fort Wrangel I purchased several articles of Indian manufacture, and saw many more, but as they all came from Queen Charlotte Islands, where I was going, I concluded to make my purchases there. Having finished our business at Fort Wrangel we were ready to leave at noon, but there being a very heavy sea and stormy SE. gale of wind all day we remained until the next morning (Sunday, 24th). At 3 o'clock we started and ran down Stachinski Strait into Duke of Clarence Strait, where we encountered a stormy head wind and heavy head sea, which retarded our progress till the next morning (Monday the 25th), when we had a terrific time with a stormy tide-rip and SE. gale, which tossed the old steamer as if she were an egg-shell. At 2 P. M. the wind and sea went down and we soon got out of Clarence Strait into Dixon's Entrance and ran across to Masset Inlet, north end of Graham Island, and anchored off the Hudson Bay Company's post at Uttewas village, two miles up the inlet, where I was kindly and most hospitably received by Alexander McKenzie, esq., the company's agent at Masset, who furnished me comfortable quarters in a cottage within the company's inclosure.

Masset is a very pretty place, situated on the east side of Masset Inlet. The land is low and level, and covered with dense foliage of evergreen

trees, spruce, hemlock, and cedar, and an undergrowth of shrubbery, rose bushes, wild currant, raspberry, and hazel, with much open grassland, on which wild strawberries are found in great quantities, of unusual size and superior flavor. Strawberries and wild-roses seem to be a specialty at Masset, and are noted by every person who visits Graham Island in June.

Masset is the site of the Indian town of Uttewas, a village containing 65 houses old and new, some of them deserted and in ruins; nearly every house has a carved column erected in front covered with heraldic or totemic designs of the family residing within. These columns are picture writings and illustrate the folk-lore of the tribe, and most of them are allegorical or mythical fables which I succeeded in deciphering, and my account of them, with illustrations, will be prepared by me for my complete monograph on Queen Charlotte Islands.

Fish.—The principal fish used by the Masset Indians for food is the halibut, which abounds in the waters of the inlet and along the whole of the north shore of Graham Island. Several varieties of salmon run up Masset Inlet, one of which, a small variety called by the Haidahs "*Swagan*" (*O. keta*, Walb.), is as fat and fine flavored as the Quenaiult salmon of the same variety, and is taken in considerable quantities by the natives, as is also a fine quality of salmon trout which are taken in weirs and traps in the small creeks which empty into the inlet. The dog salmon (*O. kisutch*, Walb.) is taken in the fall in considerable numbers for winter use. Dogfish abound, and a large quantity of their oil is collected by the Hudson Bay Company every season from the Indians.

Codfish (*Gadus morrhua*) seem to breed in the waters of Masset Inlet, where I procured several specimens from 1½ to 2 inches long, which I preserved in alcohol. Mr. McKenzie, the Hudson Bay Company's trader, purchased a few hundred pounds of true cod from the Indians which he salted in kench. I ate some of them and they were quite equal to pickled eastern cod, but the Haidahs do not seem to care for them, and when occasionally they catch the cod while fishing for halibut, they are always ready to sell them to white men. From what the Indians told me, and from my own observation, I think the true cod abound all along the northern and western coast of the whole group. These, with the *Ophiodon elongatus*, Kultus cod, or inferior cod, several species of *Sebastichthys*, and the black cod (*Anoplopoma fimbria*), lamprey, eels, herring, smelt, &c., form an extensive and plentiful variety of food-fish.

Of the plants observed by me, were *Abronia arenaria*, L.; *Lupinus Nootkatensis*, Donn; *Ranunculus Nelsoni*, Gray; *Rubus ursinus* (Cham.), Schl.; *Nutkanna mocino*, R.; *Spergularia*, Pursh., *Rosa Nutkana*, Presl; *Epilobium angustifolium*, L.; *Erigeron salsuginosus*, Gr.; *Campanula Scheuchzeri*, Gray; *Gaultheria Shallon*, Pursh.; *Mimulus luteus*, Willd; *Castilleia pallida*, Kunth; *Aquilegia formosa*, Fisch.; *Gentiana Amarella*, L.; *Pinus contorta*, Douglas; *Abies Engelmanni*, Parry; *A. amabilis*,

Forbes; *Thuya gigantea*, Nutt; *Cupressus Nutkatensis*, Lamb; *Fritillaria lanceolata*, Hook; *Fragaria Chilensis*, Duchesne; *Mahonia, Berberis Aquifolium*, &c. All of the foregoing I observed in the vicinity of Masset, and along the north shore of Graham Island. All of them are identical with the plants at Cape Flattery, Wash., except the *Cupressus Nutkatensis*, and the *Castilleia pallida*, which latter at Cape Flattery is bright red, while at Masset and elsewhere on Queen Charlotte Islands it is pale yellow.

Collections.—I was fortunate while at Masset in obtaining articles of great interest, such as models of ancient war canoes, salmon and trout nets, stone mortars, hammers, mauls, carved boxes, carved dishes of wood and horn. But the objects of the greatest interest to me were five images, three inches long, made of pure native copper by swedging and cutting. These images represent naked men and women dancing. They were worn at the belt in front of the person dancing, and made a tinkling sound.

I procured them of an old woman, who told me that they had been in her family before her great grandmother could remember. The legend respecting them is that an ancestor of hers while on a trading excursion to Sitka procured them of an Atna or Copper River Indian from the tribe of that name to the northwest of Sitka. These images were considered of such value that I was offered a large sum if I would part with them, which I declined, as I considered them the best proof I have seen of the ancient intercourse between the Aztecs of Mexico and the tribes of the Northwest coast. On my subsequent return to Victoria, Mr. Alexander McKenzie, who had come from Masset, mentioned about these copper images on board Her Majesty's ship Swiftsure, then lying in Esquinault Harbor. The surgeon of the ship, Dr. Moore, produced a silver image, 1½ inches long, which he had procured at Guatemala during the summer of 1883. This was made of pure nugget silver, and had been worn by a lady as a charm and suspended to the neck by a ribbon through a ring on the top of the head of the image. Mr. McKenzie was so struck with the similarity of design with the copper images that he borrowed it of Surgeon Moore, and had it photographed in four different positions. By comparing the two photographs the Aztec style seems to be seen in both alike.

I also found in the grave of an old doctor, or *skaga*, who had been dead fifty years or more, a couple of carved tusks, which I at first thought were those of a peccary or Mexican wild hog, but subsequent examination in Washington proved them to be the babyroussa or Asiatic wild hog, and the question is how they reached Queen Charlotte Island. A gentleman, long a resident in Japan, informs me that the Siamese junks are accustomed to trade on the African coast, running down with the northeast monsoons and returning with the southwest monsoon. These Siamese junks bring everything they can get, and trade with the Japanese and Chinese. These Japanese or Siamese junks

have been frequently wrecked on the northwest coast, and in 1831 one of these junks was wrecked on the Queen Charlotte Islands, and we have records which show that in 1694 a Japanese junk was wrecked on the Kamtchatkan coast. And at various intervals since that date we find five junks reported as being wrecked on the northwest coast, previous to the one I have mentioned in 1831. It is therefore easy to assume as a logical conclusion that the tusks of the babyroussa were procured from the wreck of some one of those old junks and became the property of the old shaman, and from their rarity were considered a highly prized medicine, which were buried with their owner as some of his treasures.

During my visit at Masset I went up the inlet and made several collections in natural history. I also took occasion to study the manners and customs of the Indians, which will be illustrated and explained in my future report.

I remained at Masset until August 6, having been detained two weeks waiting the return of the Indian who was to take me to North Island and around the west coast to Skidegate. Everything being ready, I left Masset on Monday, August 6, at 8.30 a. m., in a large canoe with seven Indians, two of whom were boys thirteen or fourteen years of age.

The canoe was owned and commanded by "Edinso," chief of North Island, where I wished particularly to make examinations. Edinso formerly lived at a village called Kioosta, on the northwest end of Graham Island, opposite North Island. We camped that night at Yatze village, a little to the west of Virago Sound, and the next morning, August 7, at 5 o'clock, we broke camp and proceeded to Jalun River, where we stopped for breakfast, the Indians meanwhile having speared ten humpback salmon (*O. gorbuscha*).

At this place is a singular exhibit of volcanic action; the lava had burst up through the superincumbent rocks as though the region had boiled like a pot. The lava was of a brick-red color, and in some places a pale sulphur yellow, and filled with bowlders and pebbles of stone blackened outside with the heat, and looking like a gigantic plum pudding. This is the first instance I have seen of such an evident volcanic action on the direct sea-beach.

From Jalun River we passed on leisurely, examining the shore from the canoe as we went. At 1.30 we passed the pillar rock at Pillar Point, and I made a sketch of the pillar, which shows quite different from Professor Dawson's sketch made from the shore, and gives a better idea of the surrounding country.

At 2 p. m. we went ashore in Parry Passage and gathered some specimens of shells, principally Heliotis and Pecten. I took the temperature of the water in Parry Passage, and found it 54°, air 60°, barometer 30, 31, and at 4 p. m. we landed at Kioosta village, where I pitched my tent and remained till the 14th, visiting in the meantime North Island, Cloak Bay, and two burial caves, in one of which I found a

number of boxes, carved and painted, each of which contains the mummified remains of former inhabitants of the near villages. The prejudices of the Indians and my overloaded canoe did not permit me to collect any specimens of those mummies, which I could easily have done if I had been in a steamer. I collected many interesting specimens of fish and mollusks, and could have procured more, but unfortunately the net which had been made for my dredge before leaving Port Townsend proved useless on trying it, as the man who made it for me had made a mistake in its shape, which made it impossible to use it in deep water. Had my dredge worked properly I could have obtained many interesting mollusks in Parry Passage, which is a rich field for the naturalist.

While at Kioosta village I made sketches of carved columns and heraldic designs and my Indian assistant, Johnny, drew, in India ink, a number of sketches illustrative of Indian legends, which when completed will furnish an interesting and valuable addition to the general report of my summer's work.

Near my camp at Kioosta village is the mausoleum or burial house of old Doctor Koontz, a famous skaga or shaman, who died many years ago and was famous in his time as a great medicine man. In his grave I found the tusks of the babyroussa mentioned.

Directly opposite this point, on the southeast portion of North Island, is Cloak Bay, made interesting by the mention of it by Captain Dixon, who named it in 1787, and Captain Marchand, a French navigator, who visited it in 1791. My notes and observations made during my week's camp at Kioosta are too extensive to be inserted in this brief synopsis.

On Tuesday, August 14, we broke camp at Kioosta and started for Skidegate at 10.20 A. M., with a fair tide which took us past Cape Knox, the extreme northwest point of Graham Island, where we encountered a tide-rip and rough cross-sea very dangerous to our heavily-laden canoe. The wind now commencing to blow fresh from the southeast with rain, we were forced to make a landing at a rocky point called Klekwakoon, which we did at 1.30 P. M., and with difficulty scrambled over a reef which extends out from the shore a considerable distance and is bare at half tide. I remained at this place till the 17th, being unable to proceed owing to constant head wind and heavy sea. I occupied the time by explorations up and down the coast, collecting curiosities and other fossils, and a few specimens of small cottoid and other fish, and making notes of the appearance of the country, which is thrown into various contorted and fantastic shapes by volcanic action. It presents a most remarkable formation, and I regretted that I did not have a photographic apparatus with me to have taken a view of the scene, which it is impossible otherwise to describe.

I found quantities of drift stuff on the beaches and in the coves, among which were logs, and broken boards of redwood from California,

showing the northerly drift along the shores of Oregon, Washington Territory, and British Columbia.

On Friday, August 17, I left Klekwakoon for the village of Tledoo, near Susk or Frederick Island, at 9 a. m., and reached camp at 2.30 p. m. There were a few Indian houses unoccupied and I took possession of one, glad to get under shelter from the rain which was falling fast.

This village, which we found vacant on our arrival, is occupied during the season by sea-otter hunters.

I had procured a chart of Queen Charlotte Islands published by the English admiralty from a map by G. M. Dawson, of the Geological Survey office, Montreal, who made a reconnaissance of the east coast of the group in the summer of 1878. The west coast has never been surveyed, but the chart of that portion was made up from an old Russian map of 1849, which is very incorrect. I kept this chart before me as I cruised along the coast in the canoe, and old Edinso, who is an excellent pilot, pointed out to me the errors in the chart as we passed along, and gave me the nomenclature of all the capes, points, bays, inlets, harbors, and islands. Frederick or Susk Island and Hippa or Nesto Island had been pretty accurately laid down, but the intervening spaces from Cape Knox to Skidegate Channel were not correctly laid down, and I marked the corrections as we came to each place. At Hippah Island in particular is a fine inlet not laid down, which makes a complete harbor of refuge for vessels bound up or down the coast. It is hidden from the view of passing vessels by Nesto or Hippah Island, and will be found when properly surveyed to be of much importance to commerce. All my new work I have marked in red ink on the copy of the chart which I sent to Washington from Victoria, August 6.

I was detained at Camp Tledoo from August 17 to August 21 by head winds and heavy breakers, which prevented our passing through the only opening in the reef to the ocean, and I occupied the time in making such collections as I could and making notes of the country for several miles each side of our camp.

On Tuesday, August 21, I started at 5.20 a m. and proceeded as far as Hippah Island, where we camped for the night with much discomfort. The following morning I made a reconnaissance of Skaloo Inlet and noted it on my map, and proceeded leisurely along, noting every point and change in the coast, till we came to Runnell Sound, when it commenced to blow from the south, with fog and rain, and we were forced to take refuge in a cove called Tchuwn, where I had to remain, wind and storm bound, till Saturday, the 25th, when I started at 7 a. m., and having camped that night in Skidegate Channel, I reached the Skidegate Oil Works at 8 o'clock Sunday morning, August 26. I at once made arrangements with the Skidegate Oil Company to assist me in procuring some black cod (*Anoplopoma fimbria*), which was done by sending Indians to the west coast, where they abound, and in a few

days I had over one hundred fine fish, which I had split like cod and salted.

I remained at Skidegate making collections of the Indians till Tuesday, September 4, when I started on a visit to the villages of Skedans, Cumshewa, and Laskeek, in the southern portion of the group, and succeeded in obtaining some rare specimens of Indian work used in their masquerade performances and highly prized by them.

At the village of Laskeek, on Tanoo Island, is the most interesting collection of columns, both heraldic and mortuary, and more monuments for the dead than I had seen in any other village. The Indian house in which I stopped is a new one, of large dimensions, built after the ancient style. In this house will be held the most extensive ceremonies that have taken place for many years, consisting of the *tomanawas* or secret performances, then the public tatooing of persons of all ages and sexes, then the masquerade dances and the distribution of presents, when several thousand dollars' worth of blankets, calico, clothing, and provisions will be given away, and the whole interspersed with feasts at different houses in the village. The occasion of this is the erection of one or more huge columns, elaborately carved with totemic devices, to show the wealth and importance of the chief in front of whose house the column will be erected. This great ceremony will take place in the fall of this year and will be well worth seeing, as it is probable that it will be the last grand display of the kind that will take place, the influence of missionaries being directed to suppressing these ancient ceremonies, in which they have succeeded, so far as regards the villages at Masset and Skidegate, where the ceremonies of the *tomanawas*, if performed at present, are greatly shorn of their honors, and I was thereby enabled to obtain many articles of ceremonial usage, which formerly no white man was suffered to look at, much less to purchase and take away.

The grand *tomanawas* of next fall will last from two to three weeks. I left Laskeek village on my return to Skidegate on Saturday afternoon, September 8th, and ran back with a fair wind to Koona village, the residence of Captain Skidance, the chief of the Klue district, where I remained till the 10th, when I arrived at Skidegate village at 8 p. m., and the following morning returned to the oil works, when I at once packed my Skidegate collection into cases, took passage on the company's little steamer Skidegate, for Victoria, leaving Skidegate on Friday, September 21st, and reaching Victoria on the afternoon of the 27th.

The result of my work may be briefly summed up as follows: I have a most interesting and valuable collection of articles of Indian manufacture. I have succeeded in introducing the black cod, a new and valuable food-fish. I have determined the locality of several new inlets and harbors on the west coast of Graham Island. I have succeeded in deciphering the true meaning of the hieroglyphics of the carved columns, which are in great profusion in every village, and the meaning of the tattoo marks on the persons of the natives. I have collected evi-

dence of the former intercourse between the Haidahs and the Aztec races of Mexico, and have accumulated an amount of information respecting the interesting tribe inhabiting the Queen Charlotte group of islands never yet made public, but which I shall elaborate in form for publication.

It may perhaps be proper for me to mention at this time, without being charged with egotism, that my work in the Queen Charlotte Islands has been considered of such value to the Province of British Columbia that I have received an official invitation to deliver a lecture before the government and legislature of that province and to other government officials in Victoria on the subject of the Queen Charlotte Islands, which lecture I propose to deliver this present month, having obtained permission so to do from Professor Baird.

Although I have accomplished much, yet there remains much of interest to science to be further investigated, not only on the Queen Charlotte Islands, but among the Haidahs of the Prince of Wales Archipelago, in Alaska; and anything intended to be done among those Indians to still further develop objects of interest should be done at once, before the tourists gather in all articles of Indian manufacture, and before the Indians themselves shall have passed away.

REPORT OF THE COMMITTEE OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE ON INDEXING CHEMICAL LITERATURE.

[Extract from the Proceedings, Vol. XXXIII, Philadelphia meeting, September, 1884.]

The Committee on Indexing Chemical Literature, appointed in 1882, respectfully presents the following report of progress.

We have the pleasure to announce that since our last report the following indexes have been published by their authors, the arrangement of material being uniform with that of those previously issued:

Ozone, *second index*, by Prof. Albert R. Leeds.

Peroxide of Hydrogen, *second index*, by Prof. A. R. Leeds.

Speed of Chemical Reactions, by Prof. R. B. Warder.

Starch Sugar, by Dr. E. J. Hallock.

Besides these a valuable contribution to chemical bibliography has been independently published on a somewhat different plan, by Prof. Albert B. Prescott and Mr. J. W. Baird. The full titles of the above will be found at the close of this report.

Two hundred and fifty copies of our report for 1883 have been sent to chemists throughout the United States, the Smithsonian Institution having kindly attended to the distribution by mail without expense to the committee. This led to correspondence with several chemists who regarded the scheme of co-operative indexing favorably, and resulted in several offers of assistance.

Prof. William Ripley Nichols offers an Index to the Literature of Carbon Monoxide.

Prof. L. P. Kinnicutt offers an Index to the Literature of Meteorites.

Dr. Henry Leffmann reports progress on his Index to the Literature of Arsenic.

Prof. C. E. Monroe does likewise with reference to an Index to the Literature of Explosives.

Prof. A. B. Prescott and Mr. J. T. Craig offer an Index to the Literature of Phosphorus.

Dr. H. Carrington Bolton has in preparation a second Index to the Literature of Uranium.

An offer was also received of an index to an element already on the list of those published, but was withdrawn as soon as the author had his attention called to the existing publication. This circumstance shows forcibly the advantage of co-operation through this committee.

We are pleased to announce that in consequence of our representations the Smithsonian Institution has consented to publish indexes to chemical

literature which shall be indorsed by this committee. The Smithsonian places a limit to the number of pages which will be printed per annum, but the limit is a generous one.

By thus securing the assistance of the Smithsonian Institution, chemists are assured of a reliable and authoritative channel of publication, together with a wide circulation, and the plan of co-operative indexing will undoubtedly receive a great stimulus.

Finally, to extend more widely acquaintance with the existing indexes, we append a complete list of those printed. A limited number of those published by the New York Academy of Sciences can be had by addressing the chairman of the publication committee of the academy, Prof. D. S. Martin, 236 West Fourth street, New York City.

Respectfully submitted.

H. CARRINGTON BOLTON, *Chairman.*
IRA REMSEN.
F. W. CLARKE.
ALBERT R. LEEDS.
ALEXIS A. JULIEN.

SEPTEMBER 4, 1884.

LIST OF INDEXES TO CHEMICAL LITERATURE.

Uranium, index to the literature of. By H. Carrington Bolton. Annals of the New York Lyceum of Natural History, Vol. IX, February, 1870. 15 pp. 8vo.

Manganese, index to the literature of; 1596–1874. By H. Carrington Bolton. Annals of the Lyceum of Natural History, New York, Vol. XI, November, 1875. 44 pp. 8vo.

Titanium, index to the literature of; 1783–1876. By Edw. J. Hallock. Annals of the New York Academy of Sciences, Vol. I, Nos. 2 and 3, 1877. 22 pp. 8vo.

Vanadium, index to the literature of. By G. Jewett Rockwell. Annals of the New York Academy of Sciences, Vol. I, No. 5, 1877. 13 pp. 8vo.

Ozone, index to the literature of; 1875–1879. By Albert R. Leeds. Annals of the New York Academy of Sciences, Vol. I, No. 12, 1880. 32 pp. 8vo.

Peroxide of Hydrogen, the literature of; 1818–1878. By Albert R. Leeds. Annals of the New York Academy of Sciences, Vol. I, No. 13, 1880. 11 pp. 8vo.

Electrolysis, index to the literature of; 1784–1880. By W. Walter Webb. Annals of the New York Academy of Sciences, Vol. II, No. 10, 1882. 40 pp. 8vo.

Speed of Chemical Reactions, literature of. By Robert B. Warder. Proceedings of the Am. Assoc. Adv. Science, Vol. 32, 1883. 3 pp. 8vo.

Starch-Sugar, bibliography of. By. Edw. J. Hallock. Appendix E to Report on Glucose, prepared by the National Academy of Sciences in response to a request made by the Commissioner of Internal Revenue. U. S. Internal Revenue, Washington, D. C., 1884. 44 pp. 8vo.

Ozone, index to the literature of (1879–1883); accompanied by an Historical-Critical Résumé of the Progress of Discovery since 1879. By Albert R. Leeds. Annals of the New York Academy of Sciences, Vol. III, p. 137, 1884. 16 pp. 8vo.

Peroxide of Hydrogen, index to the literature of; 1879–1883. By Albert R. Leeds. Annals of the New York Academy of Sciences, Vol. III, p. 153, 1884. 3 pp. 8vo.

Dictionary of the Action of Heat upon Certain Metallic Salts, including an index to the principal literature upon the subject. Compiled and arranged by J. W. Baird, contributed by A. B. Prescott, New York, 1884. 70 pp. 8vo.

ACTS AND RESOLUTIONS OF CONGRESS RELATIVE TO THE SMITHSONIAN INSTITUTION, NATIONAL MUSEUM, &c.

In continuation from previous reports.

ACTING SECRETARY OF THE SMITHSONIAN INSTITUTION.

An act to provide for the appointment of an Acting Secretary of the Smithsonian Institution.

[Public, No. 31, Forty-eighth Congress, First Session.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Chancellor of the Smithsonian Institution may, by an instrument in writing filed in the office of the Secretary thereof, designate and appoint a suitable person to act as Secretary of the Institution when there shall be a vacancy in said office, and whenever the Secretary shall be unable, from illness, absence, or other cause, to perform the duties of his office; and in such case the person so appointed may perform all the duties imposed on the Secretary by law until the vacancy shall be filled or such inability shall cease. The said Chancellor may change such designation and appointment from time to time as the Institution may, in his judgment, require.

(Approved May 13, 1884. Statutes Forty-eighth Congress, first session, chapter 44, page 21.)

PROPERTY TO BE TRANSPORTED FOR THE NATIONAL MUSEUM.

An act making appropriations for the support of the Army for the fiscal year 1885.

Provided also, That hereafter the Quartermaster-General and his officers, under his instructions, wherever stationed, shall receive, transport, and be responsible for all property turned over to them, or any one of them, by the officers or agents of any Government survey, for the National Museum, or for the civil or naval departments of the Government, in Washington or elsewhere, under the regulations governing the transportation of Army supplies, the amount paid for such transportation to be refunded or paid by the Bureau to which such property or stores pertain.

(Approved July 5, 1884. Statutes Forty-eighth Congress, first session, chap. 217, p. 111.)

SMITHSONIAN MAIL MATTER FREE OF POSTAGE.

An act making appropriations for the Post-Office Department for the fiscal year 1885.

The provisions of the fifth and sixth sections of the act entitled "An act establishing post-routes, and for other purposes" approved March 3, 1877, for the transmission of official mail matter, be, and they are hereby, extended to all officers of the United States Government, not including members of Congress, the envelopes of such matter in all cases to bear appropriate indorsements containing the proper designation of the office from which or officer from whom the same is transmitted, with a statement of the penalty for their misuse. And the provisions of said fifth and sixth sections are hereby likewise extended and made applicable to all official mail matter of the Smithsonian Institution: *Provided*, That any Department or officer authorized to use the penalty envelopes may enclose them with return address to any person or persons from or through whom official information is desired, the same to be used only to cover such official information, and indorsements relating thereto. * * *

(Approved, July 5, 1884. Statutes Forty-eighth Congress, first session, chap. 234, p. 158.)

EXECUTIVE DEPARTMENTS AT NEW ORLEANS EXPOSITION.

To enable the several Executive Departments, the Department of Agriculture, and the Smithsonian Institution to participate in the World's Industrial and Cotton Centennial Exposition to be held at New Orleans, Louisiana, under act of Congress of February tenth, eighteen hundred and eighty-three, as follows: For the War Department, fifteen thousand dollars; for the Navy Department, ten thousand dollars; for the State Department, ten thousand dollars; for the Treasury Department, twelve thousand dollars; for the Interior Department, one hundred and twenty-five thousand dollars; for the Post-Office Department, ten thousand dollars; for the Department of Agriculture, twenty-five thousand dollars; for the Department of Justice, three thousand dollars; for the Smithsonian Institution (including the National Museum and Commission of Fish and Fisheries), seventy-five thousand dollars; for necessary incidental expenses of administration by the board, including office rent, fuel, gas, stationery, telegrams, and expressage, fifteen thousand dollars; in all, three hundred thousand dollars, to be disbursed under the direction of the Board on United States Executive Departments appointed under executive order of May thirteenth, eighteen hundred and eighty-four; and no expense of any kind beyond the amounts herein provided for shall be incurred by any of the said Departments, or any officer thereof, on account of said exposition.

To enable the several Executive Departments of the Government, including the Department of Agriculture and the Smithsonian Institu-

tion, to participate in the Cincinnati Industrial Exposition, to be held at Cincinnati, Ohio, during the months of September and October, eighteen hundred and eighty-four, ten thousand dollars; and to participate in the Southern Exposition, to be held at Louisville, Kentucky, from August sixteenth to October twenty-fifth, eighteen hundred and eighty-four, ten thousand dollars; in all, twenty thousand dollars; *Provided*, That in case more than the said sums is required for the execution of this provision the same shall be paid by said Expositions.

(Sundry civil appropriation act. Approved July 7, 1884. Statutes Forty-eighth Congress, first session, chap. 332, p. 207.)

APPROPRIATIONS.

Forty-eighth Congress, First Session.

Naval Observatory.—For payment to Smithsonian Institution for freight on Observatory publications sent to foreign countries, three hundred and thirty-six dollars.

(Legislative, executive, and judicial appropriation act. Approved July 7, 1884, chap. 331, p. 184.)

War Department.—For the transportation of reports and maps to foreign countries: For the transportation of reports and maps to foreign countries, through the Smithsonian Institution, three hundred dollars.

(Sundry civil appropriation act. Approved July 7, 1884, chap. 332, p. 220.)

Public Buildings.—For paving sidewalk on south and east fronts of National Museum building, one thousand dollars.

(Sundry civil appropriation act. Approved July 7, 1884, chap. 332, p. 209.)

National Museum.—For the preservation of collections of the National Museum: For the preservation and exhibition and increase of the collections received from the surveying and exploring expeditions of the Government, and other sources, including salaries or compensation of all necessary employés, ninety-one thousand dollars. And the Director of the National Museum is hereby directed to report annually to Congress the progress of the Museum during the year and its present condition.

For transfer and arrangement of the collections of the American Institute of Mining Engineers, presented to the Government, including expenses already incurred, ten thousand dollars.

For the preservation of collections of the National Museum in the Armory Building: For care of the Armory Building and grounds and expense of watching, preservation, and storage of the duplicate collections of the Government and of the property of the United States Fish

Commission contained therein, including salaries or compensation of all necessary employés, two thousand five hundred dollars.

For furniture and fixtures of the National Museum: For cases, furniture, and fixtures required for the exhibition of the collections of the United States National Museum, and for salaries or compensation of all necessary employés, forty thousand dollars.

For heating and lighting the National Museum: For expense of heating, lighting, and telephonic and electrical service for the new museum building, six thousand dollars.

Sundry civil appropriation act. Approved July 7, 1884, chap. 332, p. 214.)

Smithsonian Institution.—For finishing, heating, gas-fitting, plumbing, and completely furnishing the eastern portion of the Smithsonian Institution, and for finishing the fourth and fifth stories, including liabilities already incurred, fifteen thousand dollars.

For North American ethnology, Smithsonian Institution: For the purpose of continuing ethnological researches among the American Indians, under the direction of the Secretary of the Smithsonian Institution, including salaries and compensation of all necessary employés, forty thousand dollars.

(Sundry civil appropriation act. Approved July 7, 1884, chap. 332, p. 214.)

International Exchanges, Smithsonian Institution.—For the expenses of an international exchange of books, documents, and productions of the United States with foreign countries, in accordance with the Paris convention of 1877, including salaries and compensation to all necessary employés, to be expended under the direction of the Secretary of the Smithsonian Institution, ten thousand dollars.

(Consular and diplomatic appropriation act. Approved July 7, 1884, chap. 333, p. 235.)

Refund of Duty on Sevres Vase presented to National Museum.—To refund the duty paid by L. Strauss and Sons, May 23, 1879, upon a Sevres vase presented by them to the National Museum, two hundred and ten dollars and fifty cents.

(Act to supply deficiencies. Approved, July 7, 1884, chap. 334, p. 246.)

Henry Statue.—For expense of freight on statue of Joseph Henry from Rome to Washington, and all expenses by the Smithsonian Institution connected with the erection and ceremonies of unveiling said statue, nine hundred dollars.

(Act to supply deficiencies. Approved, July 7, 1884, chap. 334, p. 246.)

ELECTION OF REGENTS.

Joint resolution 15, filling an existing vacancy in the Board of Regents of the Smithsonian Institution.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the existing vacancy in the Board of Regents of the Smithsonian Institution, of the class "other than members of Congress," shall be filled by the reappointment of NOAH PORTER, of Connecticut, whose term of service has expired.

(Approved, March 3, 1884. Statutes, Forty-eighth Congress, first session, p. 269.)

Joint resolution 26, filling an existing vacancy in the Board of Regents of the Smithsonian Institution.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the existing vacancy in the Board of Regents of the Smithsonian Institution, of the class "other than members of Congress," occasioned by the resignation of Peter Parker, be filled by the appointment of JAMES C. WELLING, of the city of Washington.

(Approved, May 13, 1884. Statutes, Forty-eighth Congress, first session, p. 272.)

GENERAL APPENDIX

TO THE

SMITHSONIAN REPORT FOR 1884.

ADVERTISEMENT.

The object of the GENERAL APPENDIX is to furnish summaries of scientific discovery in particular directions; occasional reports of the investigations made by collaborators of the Institution; memoirs of a general character or on special topics, whether original and prepared expressly for the purpose, or selected from foreign journals and proceedings; and briefly to present (as fully as space will permit) such papers not published in the "Smithsonian Contributions" or in the "Miscellaneous Collections" as may be supposed to be of interest or value to the numerous correspondents of the Institution.

RECORD OF SCIENTIFIC PROGRESS FOR 1884.

INTRODUCTION.

While it has been a prominent object of the Board of Regents of the Smithsonian Institution, from a very early date in its history, to enrich the annual report, required of them by law, with scientific memoirs illustrating the more remarkable and important developments in phyical and biological discovery, as well as showing the general character of the operations of the Institution, this purpose was not carried out on any very systematic plan until the year 1880. Believing however that an annual report or summary of the recent advances made in the leading departments of scientific inquiry would supply a want very generally felt, and would be favorably received by all those interested in the diffusion of knowledge, the Secretary had prepared for the report of 1880, by competent collaborators, a series of abstracts showing concisely the prominent features of recent scientific progress in astronomy, geology, physics, chemistry, mineralogy, botany, zoölogy, and anthropology.

The same general programme has been followed in the subsequent reports, with the inclusion of geography and meteorology in the list of subjects. The contributors to this record for the present year, and their several departments or topics, remain the same as in the last report, excepting that the summary of the progress of geology and of that of botany for the year have been unavoidably omitted. A *résumé* of the subjects vulcanology and seismology for the years 1883 and 1884 has been prepared for this report by Prof. Charles B. Rockwood, of Princeton College; and a review of the bibliography of North American invertebrate palæontology for the year has been prepared by Mr. John Belknap Marcou.

With every effort to secure prompt attention to all the more important details of such a work, various unexpected delays frequently render it impracticable to obtain all the desired reports in each department within the time prescribed. In such cases it is designed, if possible, to bring up deficiencies and supply them in subsequent reports.

The value of this annual record of progress would be much enhanced by an enlargement of its scope, and the inclusion, not only of such branches as mathematics, physiology, pathology and medicine, micros-

copy, &c., but also of the more practical topics of agricultural and horticultural economy, engineering, mechanics, and technology in general; but the space required for such larger digest seems scarcely available in the present channel.

It is hardly necessary to remark that in a summary of the annual progress of scientific discovery so condensed as the present, the wants of the specialist in any branch can be but imperfectly supplied; and very many items and details of great value to him must be entirely omitted. While the student in a special field of knowledge may occasionally receive hints that will be found of interest, he will naturally be led to consult for fuller information the original journals and special periodicals from which these brief notices or abstracts have been compiled.

The plan of devoting some 350 pages of the annual report to such a compilation is not designed to preclude the introduction into the "General Appendix," as heretofore, of special monographs or discussions that may prove interesting to the scientific student.

SPENCER F. BAIRD.

ASTRONOMY.

By Professor Edward S. Holden,
Director of the Washburn Observatory.

The following record of the progress of Astronomy during the year 1884 is in continuation of the records for past years, and it is given in essentially the same form. Abstracts of some of the most important papers of the year are arranged under their appropriate heads. Other papers, equally important, have been omitted, since they do not lend themselves to condensation.

To the professional astronomer these abstracts may serve as a convenient collection of notes. They are, however, primarily intended for the large and increasing class of those who are interested in astronomy, but whose acquaintance with the subject is more general than special. The writer has made free use of reviews, etc., which have appeared in the various scientific journals, more especially in *Nature*, *The Observatory*, *Bulletin Astronomique*, *Sirius*, *The Sidereal Messenger*, *The Athenæum*.

CONSTRUCTION OF THE HEAVENS; NEBULAR HYPOTHESIS, ETC.

On the distribution of the stars in the northern hemisphere, by Prof. H. Seeliger.

[ABSTRACT.]

As is well known, the *Durchmusterung* of Argelander contains the positions and magnitudes of all stars visible in a 3-inch comet-seeker, with a power of 10, from the north pole to —2° declination. Professor Schoenfeld has completed a similar *Durchmusterung* from —2° to —23° which is not yet published. The stars of these lists are between the 1.0 and 9.5 magnitudes (the last approximate only). In 1869 von Littrow had the stars of the northern D. M. counted by *magnitudes* and by *declination*. That is, he had the zones of 1° wide in declination counted, so as to exhibit the number of stars of each tenth of a magnitude. Unfortunately he did not separate the stars so as to exhibit the numbers in right ascension also, as he might easily have done. Professor Seeliger, of Munich, has just completed a count of this kind. He was led to do this, he says, because there was no such count in existence, and one was needed. It is clear that a kind of astronomical "clearing-house," where

accounts can be adjusted, is also needed! A count of this kind exists in MS. at the Bonn Observatory (see Bonn Obs., vol. v), but is not accessible. The Washburn Observatory prints in its vol. III, the beginning of a count of this kind (from —2° to + 13°), which was stopped on hearing of Professor Seeliger's. Professor Seeliger appears also to be unaware that Littrow's count has been repeated by Mr. Peirce (*Annals H. C. O.*, vol. IX)! With this digression, which is not uninstructive, we return to Professor Seeliger's important paper. He has then counted the stars of the D. M. accurately, and by R. A. as well as Decl. and Mag. Instead of keeping magnitudes down to the tenths, he has wisely selected the following classes:

1. Containing stars from 1.0 to 6.5 mags., inclusive.
2. Containing stars from 6.6 to 7.0 mags., inclusive.
3. Containing stars from 7.1 to 7.5 mags., inclusive.
4. Containing stars from 7.6 to 8.0 mags., inclusive.
5. Containing stars from 8.1 to 8.5 mags., inclusive.
6. Containing stars from 8.6 to 9.0 mags., inclusive.
7. Containing stars from 9.1 to 9.5 mags., inclusive.

The number of stars for each 20^m of R. A. and each 1° of Dec. was counted. These numbers have been united into sums giving new numbers of stars in areas of 20^m in R. A. by 5° in Dec. The latter tables are to be printed by the Munich Observatory.

Professor Seeliger's paper contains the number of stars for each area of 40^m in R. A. by 5° in Dec., the stars of each class 1–7 being enumerated separately. There are, in the northern sky, 4,120 objects of class 1; 3,887 class 2; 6,054 class 3; 11,168 class 4; 22,898 class 5; 52,852 class 6; 213,973 class 7; 314,952 in all, besides 126 nebulæ, variables, etc. That is 315,078 in all, by Professor Seeliger's count. Argelander gives 315,089. To deal with this mass of figures, Professor Seeliger divides the sky into 8 zones. Zone 1 has its center at the north pole of the Milky Way, and extends to Galactic Polar Distance 20°; zone 2 extends from G. P. D. 20° to 40°; zone 3, from 40° to 60°; zone 4, from 60° to 80°; zone 5 (containing the Milky Way itself) from 80° to 100°, and so on to G. P. D. 140°.

The number of stars (of each class) per zone is next determined; and next the number of stars (of each class) in each 1° square. We may quote the figures for class 1 and classes 2–7 taken together:

	Class 1.	Classes 2–7.
Zone 1	0.15	8.51
2	0.15	8.95
3	0.17	11.02
4	0.21	16.77
5	0.27	24.60
6	0.25	18.92
7	0.15	11.59
8	0.12	10.19

This table shows the influence of the Milky Way most markedly; but if changed so that the number of stars in zone 5 is always 1.00, it becomes even more interesting.

	Class 1.	Classes 2–7.
Zone 1	0.55	0.35
2	0.57	0.36
3	0.64	0.45
4	0.79	0.68
5	1.00	1.00
6	0.91	0.77
7	0.57	0.47
8	0.43	0.41

If we call these last numbers D, and if we form $\frac{1-D}{7}$, these numbers may be called the *gradients* (G), expressing the rapidity of increase of number of stars as we approach the Milky Way. The values of G are—

Class 1	0.36	Class 5	0.44
2	0.48	6	0.45
3	0.42	7	0.45
4	0.47	8	0.52

Classes 2–7, 0.50.

It thus appears probable that G is greater for the fainter stars, but not so much greater as has been commonly supposed. For stars of the *mags.* 1, 2, 3, and of the *mags.* 4, 5, 6, G results 0.14 and 0.19. These numbers show an important difference between the bright and the faint stars. If we were allowed to assume that stars even fainter than 9.5 would continue to show the constant gradient that these show it would follow that our stellar system was not to be considered as a flat disk. but rather more or less spherical, with the stars concentrated near its medial plane (the Milky Way).

The author next proceeds to compute the center of gravity of each class of stars, and its position is—

	R. A.	Dec.	$\left(\frac{R}{r}\right)$
Class 2	$= 23^h\ 30^m$	$+ 79^\circ.5$	0.58
3	22 32	+ 81 .5	0.58
4	23 10	+ 79 .7	0.56
5	23 7	+ 79 .3	0.53
6	23 9	+ 78 .3	0.51
7	24 14	+ 77 .3	0.51

The last column gives the ratio $\frac{R}{r}$ for each class; where R is the distance of the center of gravity of *all stars* of the class, *r* that of any star of that class.

The full interpretation of these numbers can only be made when

Schoenfeld's D. M. is published. Certain further conclusions may also be drawn from the author's figures. This paper is the most important which has appeared on this very interesting question since the publication of Dr. Gould's *Uranometria Argentina.*

ASTRONOMICAL CONSTANTS.

New investigations on the constants of precession.—In one of the last meetings of the "Niederrheinische Gesellschaft für Natur und Heilkunde," Dr. Schoenfeld presented a lately published article by Dr. F. Bolte, entitled "Investigations on the Constants of Precession, based upon the Star catalogues of Lalande and Schjellerup." The writer here makes the first attempt to take into consideration the systematic proper motion of the fixed stars in the determination of these important constants; while up to this time those parallactic changes of star positions, at most, have been considered which are due to the motion of the solar system. Such systematic proper motions may be of different kinds, but the most obvious assumption is that they occur in planes which are but slightly inclined to the plane of the Milky Way. This is the idea that the writer has adopted, and he has applied it to the 3,300 stars common to the above mentioned catalogues, supplementing a treatise of Dreyer's, in which the latter discusses the R. A.'s of these stars, by considering their declinations at the same time. The result for the precession is a very good substantiation of Struve's constant, now so commonly used in our almanacs; as to the assumed common motion of the stars however, the result is an entirely negative one, for its value, determined as 0″.4 per century, is much less than its probable error.

The speaker touched upon various possible explanations of this interesting result, particularly this: That the attraction of the Milky Way upon the individual stars may be counteracted by the attraction of the nebulæ which are mostly thickly clustered about the poles of the Milky Way.—From *Sirius*, February, 1884.

CATALOGUES OF STARS.

Progress of the zone-observations of stars 1–9 *mag. of the German Astronomical Society.—Kasan:* Zone 80°–75°. The printing is begun and it gives the star places reduced to the beginning of the year. The reduction to 1875 is still to be made.

Dorpat: Zone 75°–70°; and *Christiania:* Zone 70°–65°. The work for these zones is nearly completed.

Helsingfors-Gotha: Zone 65°–55°. The printing is well advanced.

Cambridge (U. S.): 55°–50°. The printing has begun; the work of reduction to 1875.0 is about half done. A certain number of stars require reobservation. The probable errors of a position are about $0^s.08$ and 0″.8.

Bonn: Zone 50°–40°. The observations are not yet finished, although near to completion. The mean difference of R. A. of a star from two observations is about $0^s.08$ and $1''.1$. Investigations of the effect of the magnitude of a star on its deduced R. A. show a difference (faint *minus* bright) less than $+0.^s008$ in the mean.

Lund: Zone 40°–35°. The work is nearly completed.

Leyden: Zone 35°–30°. The observations are finished.

Cambridge (England): Zone 30°–25°. Thirty-eight thousand five hundred and fifty-nine observations have been made from 1872 to 1883. Three hundred and eighty-four stars have not yet been observed once; 614 have been observed only once; the rest of the total number, 10,691, twice or oftener.

Berlin: Zone 25°–20°. Dr. Becker's observations are completed. Observations on 13 nights of 247 stars show that fainter stars are observed later by $0^s.007$ for each magnitude.

Berlin: Zone 20°–15°. Dr. Auwers has long since completed the observations. The reductions are not completed.

Leipsic: Zone 15°–5°. The observations are nearly completed for the zone 15°–10°, and those for 10°–5° are in progress.

Albany: Zone 5°–1°. The observations are completed, and the reductions very far advanced.

Nikolaieff: Zone +1°–2°. The observations are still in progress.

Determining stars for the southern zones of the Astronomische Gesellschaft.—These 303 stars are being observed at various observatories, as follows:

Cape of Good Hope.—The observations are finished and each star has been observed at least twelve times. The results of observation are all reduced, and for the final publication there are needed investigations of the flexure, the latitude, the refraction, the personal equations of the observers depending (*a*) on the star's magnitude, (*b*) on its declination. The division errors for each 1° have been investigated. The circle is not reversible. The flexure is to be investigated by means of collimators made specially for the purpose by Troughton & Simms. Each collimator is furnished with a reversing apparatus and a level, and the horizontal point can thus be determined, either north and south. Combining these horizontal points with nadir-points will determine whether the flexure is the same looking north and south. The latitude is to be determined from observations of circumpolar stars, at both culminations (already observed in 1880 '81 '82 '83). The declinations of these stars are to be determined by observing their azimuths at greatest elongations E. and W., with the 3-foot theodolite of the India survey. South stars culminating at zenith-distances, equal to those of the circumpolar stars, are to be observed by Talcott's method. These observations are to be combined by Kapteyn's method.

For the refraction, the Cape has observed a number of north stars (near the zenith of Leyden) and zenith stars (near the horizon of Ley-

den) which have also been observed at Leyden. A discussion of these declinations is now in progress.

For *eliminating* personal equation depending on the direction of the star's motion, each star has been observed over half the wires in the usual way, and over the other half through a reversing prism.

All the observers make the clock *slower* when the stars move across the field from left to right.

Leyden Observatory.—Since 1881, 427 observations have been made, and 1,124 in all; 165 of the 303 stars have been observed once or oftener.

Melbourne Observatory.—The observations will be begun in 1883.

Sydney Observatory.—Sydney also proposes to observe these stars.

Naples Observatory.—The observations will be begun in January, 1884.

Washburn Observatory.—The observations were begun in May, 1884, and up to January 1, 1885, 1,800 observations have been made and are completely reduced. The probable error of a single decl. is $0''.41$. The constant of refraction of the Pulkowa Refraction tables requires a correction of $+ 0''.30$.

*A uniform ephemeris of the clock-stars.**—A noteworthy feature in the progress of our astronomical annuals is the rapid increase that has taken place within a few years in the number of the clock-stars. This increase seems to have been brought about chiefly by the influence of the Berlin list of 539 stars, which was published for the use of astronomers who were engaged in observing the zones of the northern heavens. The convenience of this list for the use of observing parties in the field seems to have led to the large increase that we find in the annual publications. For the year 1886 the *Nautical Almanac* gives the mean positions of 198 stars, the *Connaissance des Temps* of 316, the *Berliner Jahrbuch* of 622, and the *American Ephemeris* of 383 stars.

That this great increase in the number of clock-stars has some advantages will not be denied, but, on the other hand, there seem to be some disadvantages that ought to be considered. In the first place the mean positions of the stars given in the different publications do not agree as well as might be expected when the great number of observations of these stars is taken into account and the number of years over which the observations are extended. These differences of position are indeed small, and their influence on the observed positions of other stars and planets cannot be great; but we have already examples in astronomy of the extension of such small errors into large catalogues of stars and of their development into periodic errors.

The constants for the reduction of the clock-stars from one epoch to another, and to apparent position, are now so well known, and the adopted values are so nearly the same, that the differences produced by the various reductions are frequently neglected; but even here it seems there is room for improvement. At the present time the values of the

* Astr. Nachr., No. 2602.

constants of reduction are known to a good degree of approximation, and it ought not to be difficult for astronomers to unite on a common system of values of these constants and also on a uniform notation to be used in reductions. The great advancement in stellar astronomy made by Bessel in his "Tabulæ Regiomontanæ" seems to have been partly disregarded and lost, and his methods for bringing the labors of many observers into harmony, and of making them all tend towards the advancement of the science, have sometimes been overlooked and forgotten.

Again, if a large list of clock-stars is at hand, the astronomer is apt to make his work purely differential. In many cases this may be his best course, but such work would be more easily reduced and compared if it could all be referred to a common system of clock-stars. The computation of systematic errors would not be avoided, but the work would be made easier and more certain.

In order to obtain an extensive and convenient ephemeris of the clock-stars, suitable for general use, it would be better to make such a work a special publication. In this way the adoption of the mean positions of the stars and the selection of the constants of reduction and the system of notation could be brought under the direction of one office. The work should be so elaborate that the apparent position of a star could be interpolated with ease and certainty for any time, but even with such an extension the cost of publication would not be great. I hope that the Astronomische Gesellschaft may be willing to undertake a work of this kind. (A. Hall, *Washington*, 1884, *May* 30.)

Positions of polar stars.—Vols. I and II of the *Annals of the Observatory of Kiew* are largely devoted to the observations made of a considerable number of circumpolar stars with the object of forming a standard set of places. These two interesting volumes cannot be epitomized here, but reference may be made to a very complete review of them in the *Bulletin Astronomique*, Vol. I, p. 139, by M. Callandreau.

Schoenfeld's Durchmusterung, from $-2°$ *to* $-23°$.—At the Vienna meeting of the German Astronomical Society, Dr. Schoenfeld gave an account of the progress of his work since the Strassburg meeting.

699.3 hours of R. A. with 363,351 star-positions have been observed. The principal catalogue now contains 113,706 stars between $-2°$ and $-23°$ and 1,161 stars near these limits. In 21^h, *i. e.*, from $9^h\ 0^m$ to $6^h\ 0^m$, the work is completed. (This work is now done; 1885.)

It is expected to begin the printing of the principal catalogue in May or June, 1884. Probably some 40,000 stars brighter than 9.1 mag. exist in the region.

Greenwich catalogue of stars.—The volume of *Greenwich Observations* for 1882 has been published. It was mentioned in the Astronomer Royal's report to the board of visitors that this had been passed for press early in May. It is the first volume relating to a year of which the work was wholly under the direction of Mr. Christie, as Sir George

Airy resigned on the 15th of August, 1881. In his report, alluded to above, Mr. Christie stated that the next great catalogue of stars formed from the Greenwich observations would not be commenced until after the end of next year, as it wa; intended to make it embrace, like the preceding, the stellar work of nine years, ending with that of 1885, as the last included the observations of 1876.

New catalogues of stars.—The Armagh Observatory is preparing for the press a second Armagh catalogue of about 3,000 stars, most of which have been observed from three to five times with the mural circle.

The Washburn Observatory will print in its vol. III, now in press, a catalogue of 1,001 southern stars, observed by Professor Tacchini in 1867, '68, '69, and reduced by Rev. Father Hagen, S. J., and Professor Holden.

Catalogue of 6,000 *stars.*—Professor Schering writes that the Göttingen catalogue of 6,000 stars is in process of preparation for printing. For account of it see Göttinger *Nachrichten*, 1864, July 13.

PARALLAX OF STARS.

*Parallax-hunting at Dunsink.**—For some years past Professor Ball has employed the south refractor of the Dunsink Observatory in making a systematic Search for stars with a large annual parallax. The third part of the *Observations* contains the results of measures of 42 objects selected for this purpose, and the volume now before us contains the observations of 368 additional objects.

In making out a working list of stars suitable for examination, Professor Ball has been guided by various considerations. Of course stars with large proper motion would be naturally included, though the presumption of nearness founded on great proper motion can hardly be said to be justified by the results of observation. Many red stars and variable stars have been put on the working list. It has been suggested by Mr. Stoney that some of the former may owe their color to being very small, and therefore very close to us. There is also reason to believe that some of the variable stars are really very small, and that therefore, as we see them, they must be comparatively near us.

Several other stars have also been included, which were chosen on different grounds.

In the reconnoitering observations carried out by Professor Ball every object is observed twice. The first observation is made when the star is at one of the extremities of the major axis of the parallax-ellipse, the second observation is made after an interval of six months, when the star has moved to that part of the parallax-ellipse which is at the other extremity of the major axis. The observation consists in the measurement of the distance and position angle of the object under examination

* Astronomical Observations and Researches made at Dunsink. Fifth part, Dublin, 1884.

with regard to a suitable comparison star, which for the telescope and micrometer used should not be more than 300″ distant from the star whose parallax is to be examined, and not fainter than the 10th magnitude.

By comparing the two observations referred to above it can be determined whether the object under examination has a parallax of any considerable amount or not. Of course it would have been preferable to make the observations at times when the effect of parallax on the relative positions of the star under examination and the comparison star would be greatest; but the determination of these times would have entailed some additional labor, and Professor Ball has been satisfied with the simpler process described.

Whenever the observations have suggested the existence of a measurable parallax, the objects have been observed again, and when necessary a complete series of observations has been made.

As might be expected, the results of the present work are mainly of a negative character; still the observations will be useful to future parallax seekers, and are also valuable as a small instrument of that complete survey of the heavens which is still a desideratum. The observations are, however, sufficient to enable us, in Professor Ball's opinion, to assert that the parallax of these stars is certainly less than a second of arc, and most probably less than half a second of arc. It is, of course, possible that no star in the heavens has a parallax larger than a second. Professor Ball somewhat naïvely remarks he often thinks that there certainly is not. It must, however, be remembered that comparatively very few stars have been examined with this object in view, and the induction is founded on really a very small number of instances. Professor Ball's parallax-hunting is therefore a class of work which ought to be done, and it is most satisfactory to find that it is being done so skillfully and well.

In the present volume there are also included some positive fruits of Professor Ball's work, viz, determinations of the parallax of 61 (B) Cygni (from differences of declination), of Groombridge 1618, and of 6 (B) Cygni.*

The following are the results:

Star.	Magnitude.	Parallax.	Magnitude of comparison star.
61 (B) Cygni	5.9	+0″.4676 ± 0″.0321	9.5
Groom. 1618	6.8	+0″.322 ± 0″.023	8.8
6 (B) Cygni	6.5	+0″.482 ± 0″.054	10.5

These three stars have large proper motions.

As these determinations have, we believe, been previously published

Flamsteed's 6 Cygni is B of that constellation; the star here referred to is Groombridge 2789, and the appellation "6 Cygni" is taken from Bode.

in scientific periodicals, they need not be further alluded to here. We may, however, point out that the series of measures of 61 (B) Cygni alluded to on page 159 as having been made at Moscow between 1863, May 16, and 1866, October 13, and published in *Annales de l'Observatoire de Moscow*, vol. VII, 1 livraison, page 79 *et seq.*, have been reduced by M. Socoloff (*loc. cit.*, vol. VIII, 2 livraison), who finds—

From measures of distance,

$$\text{parallax of 61 Cygni} = +0''.4598 \pm 0''.0550.$$

From measures of position,

$$\text{parallax of 61 Cygni} = +0''.4222 \pm 0''.0342.$$

From combination of measures,

$$\text{parallax of 61 Cygni} = +0''.4330 \pm 0''.0291.$$

The observations were made by Schweizer, Struve's comparison star (9.4 mag.) being used.—*A. M. W. D.*, "*The Observatory*," November, 1884, p. 335.

From a report of a lecture by Dr. Gill on stellar parallax the following is extracted:

Parallaxes of stars which have been determined in the northern heavens with considerable accuracy.

Name of star.	Magnitude.	Proper motion.	Parallax.
		"	"
61 Cygni	6	5.14	0.50
Lalande 21185	7½	4.75	0.50
α Tauri	1	0.19	0.52
34 Groombridge	8	2.81	0.29
Lalande 21258	8½	4.40	0.26
AOe 17415	9	1.27	0.25
σ Draconis	5	1.87	0.25
α Lyræ	1	0.31	0.20
ρ Ophiuchi	4½	1.0	0.17
α Bootis	1	2.43	0.13 ?
Groombridge 1830	7	7.05	0.09
Bradley 3077	6	2.09	0.07
85 Pegasi	6	1.38	0.05

Results of recent researches on the parallax of stars in the southern hemisphere.

Name of star.	Observer.*	Star's magnitude.	Annual proper motion in arc.	Parallax.	Star's distance in light units, or number of years in which light from star would reach the earth.	Velocity of star's motion in miles per second at right angles to line of sight.
			"	"		
α Centauri	G. & E.	1	3.67	0.75	4.36	14.4
Sirius	G. & E.	1	1.24	0.38	8.6	9.6
Lacaille 9352	G.	7½	6.95	0.28	11.6	73
ε Indi	G. & E.	5½	4.68	0.22	15	63
o_2 Eridani	G.	4½	4.10	0.17	19	69
e Eridani	E.	4½	3.03	0.14	23	64
ζ Tucanæ	E.	4	2.05	0.06	54	101
Canopus	E.	1	0.00	Insensible.	....	....
β Centauri	G.	1	.....	Insensible.	....	....

* G. = Gill; E. = Elkin.

"Time does not permit me to go into more detail as to each of these separate results, full of interest though they are, and each of them representing months of labor.

"My object now is to generalize, to point out the conclusions that must be drawn from this table and to see what are the broad lessons that it teaches us.

"A glance is sufficient to show that neither apparent magnitude nor apparent proper motion can afford a definitive criterion of the distance of any fixed star—that different stars really differ greatly in absolute brightness and in absolute motion.

"The great cosmical problem that we have to solve is not so much what is the parallax of this or that particular star, but we have to solve the much broader questions—

"1. What are the average parallaxes of stars of the first, second, third, and fourth magnitudes, compared with those of fainter magnitude?

"2. What connection does there subsist between the parallax of a star and the amount and direction of its proper motion, or can it be proved that there is no such relation or connection?

"With any approximate answer to these questions we should probably be able to determine the law of absorption of starlight in space, and be provided with the data at present wanting for determining with more precision the constant of precession and the amount and direction of the solar motion in space. And who can predict what hitherto unknown cosmical laws might reveal themselves in the course of such an investigation?

"It is important to consider whether such a scheme of research is one that can be realized in the immediate future, or one that can only be carried to completion by the accumulated labors of successive astronomers.

"I have very carefully considered this question from a practical point of view, and I have prepared a scheme, founded on the results of my past experience. I have submitted that scheme for the opinion of the most competent judges, and in their opinion, as well as my own, the work can be done, with honest hard work, for one hemisphere, within ten years. I have offered to do that work for the southern hemisphere with my own hands, and a proposal for the necessary instruments and appliances is now under the consideration of my lords commissioners of the admiralty. I need hardly add that in this matter I look confidently for that complete consideration and that efficient support which I have never failed to receive at their hands since I have had the honor to serve them.

"The like work will be undertaken for the northern hemisphere by my friend, Dr. Elkin, who is now in charge of the heliometer at Yale College, in America. It is at present the finest instrument of the kind in the world.

"I most earnestly trust that we may be granted health and strength

for this work, and that no unforeseen circumstances will prevent its complete accomplishment." (*Nature.*)

DOUBLE STARS.

"*Mr. Burnham's double-star measures.*—The recently published volume of the *Memoirs of the Royal Astronomical Society* contains a further series of measures of double stars by Mr. S. W. Burnham, made with the 18-inch refractor of the observatory at Chicago. This series comprises measures of 151 double stars discovered by this eminent observer, which brings up the number of such objects discovered by him during the last ten years to no fewer than 1,013, amongst which are included some of the most interesting stars of this class; also measures of a selected list of double stars, 770 in number, made chiefly in the years 1879 and 1880, with an appendix, the results of observations of several objects as late as the middle of the past year. Every one who is interested in this branch of astronomical science will read with much regret one remark in Mr. Burnham's introduction. He writes: 'The present catalogue will conclude my astronomical work, at least so far as any regular or systematic observations are concerned.' He expresses himself modestly respecting his own labors: 'In a field so infinitely large, one can accomplish but little at the most, and how much, or how little, the astronomers of a few centuries hence can perhaps best decide. - - - At this time I may venture to claim that my work in this field has been prosecuted with some enthusiasm, and for its own sake only, and that my interest has not been divided among several specialities.'

"But a higher estimate of Mr. Burnham's work in this particular line of observational astronomy to which he has devoted himself may be justly taken. To read of the discovery of upwards of a thousand double stars within a limited period by one observer, we might almost suppose we were living in the days of Sir William Herschel, when the heavens were comparatively an open field, and had not undergone the wide and close exploration which they had done when Mr. Burnham commenced his work. He has had, it is true, the advantage of instruments of the finest class, and, we may believe, an unusually acute vision; but he must have exercised an extraordinary and most meritorious amount of patience, perseverance, and care in the discovery and accurate measurement of such a list of double stars, and it will be gratifying to the astronomical world that such well-directed exertions have met with so exceptional a success.

"Among the more noteworthy stars included in Mr. Burnham's new catalogue (the fourteenth), which may be considered a continuation of that published in vol. XLIV of the same *Memoirs*, the following may be mentioned:

"1. 126 Tauri (β 1007), 'a most remarkably close and difficult pair, one

of the closest known;' magnitudes 6.0 and 6.2. With a power of 1,400 there was only a slight elongation.

"2. B. A. C. 346; Mr. Burnham thinks the principal star may be variable, and he is certainly correct in his surmise. Heis gives it as a naked-eye star $6.^{m}7$, Gould $7.^{m}0$, and it has been several times noted 8^{m}; while the writer has recorded it as low as 9^{m}.

"3. β 117; a star with a proper motion, according to Argelander, of $0''.438$; measures in 1883 show a common motion of the components; their distance is $2''.2$.

"4. ζ Sagittarii; detected by Winlock, probably a retrograde motion of 225° in less than fourteen years; and evidently a change of 48° in less than three years, by Mr. Burnham's measures alone. It is an object for large instruments in the other hemisphere.

"5. β Delphini (β 151).—A very rapid binary; since its detection by Mr. Burnham, in 1873, there has been an increase in the angle of about 180°, and a diminution in distance from $0''.6$ to $0''.25$. He thinks 'it may prove to have, with the single exception of δ Equulei, the shortest period known.'

"Mr. Burnham collects the measures of δ Equulei, and infers a period of revolution of about 10.8 years. Measures should be easy again in 1885.

"6. 85 Pegasi (β 733) —The close pair was not measurable in 1882; the angle was about 333° at the epoch 1883.75. The mean annual motion is about 12°.5, at which rate the period would be less than thirty years.

"In the introduction to the catalogue will be found references to the publications where the thirteen previous ones are to be found." (*Nature.*)

MOTIONS OF STARS IN THE LINE OF SIGHT.

From the Astronomer Royal's report we learn that—

"For the determination of motions of stars in the line of sight, 412 measures have been made of the displacement of the F line in the spectra of 48 stars, 91 measures of the *b* lines in 19 stars, and two measures of the D lines in one star, besides measures of the displacements of the *b* and F lines in the spectra of the east and west limbs of *Jupiter*, and in the spectra of *Venus* and *Mars*, and comparisons with lines in the moon or sky spectrum made in the course of every night's observations of star-motions, or on the following morning, as a check on the adjustment of the spectroscope. Some preliminary measures have also been made of the F line in the spectrum of the Orion Nebula. The progressive change in the motion of *Sirius*, from recession to approach, alluded to in the last two reports, is fully confirmed by numerous observations since last autumn, and a change of the same character is indicated in the case of *Procyon*. A discussion of the measures of all the stars observed here, on which I am now engaged, shows that the results of the four periods—1875, June, to 1877, May; 1877, June, to 1880, December; 1881, January, to 1882, March 10; 1882, March 11, to 1884, March 31; in

each of which the instrumental conditions were different—accord generally within the limits of the probable errors, and that there is no systematic change from recession to approach, so that the presumption against error arising from defective instrumental adjustment appears to be strong." (*Nature.*)

PHOTOMETRY OF STARS.

The new volume of *Annals of the Observatory of Harvard College* is in many respects the most interesting and important of any of them, for it embodies the results of three years' work with an entirely new and unique instrument in a field hitherto but little explored, which Professor Pickering, the director, has made almost entirely his own by the invention of novel and efficient apparatus, and by the energetic accumulation, discussion, and prompt publication of results.

The observations described in this volume consist of 94,476 separate measurements of the brightness of 4,260 stars, all those visible to the naked eye from the North Pole to 30° of south declination, and many somewhat fainter. They were made by Professor Pickering, the director, aided by Messrs. Searle and Wendell, assistants in the Harvard College Observatory, using the new meridian photometer, devised by the director.

With this photometer each of the 4,260 stars was compared, when near the meridian, with the pole star on at least three nights, and many of them on six or more. In these comparisons both stars are seen under the same magnifying power and on the same background, so that the differential effect of moonlight or twilight is eliminated, and any error due to local cloudiness or haziness over one star is sufficiently guarded against by the number of different nights and the repetition of the observations where this is suspected. Two persons work at the same time, the observer managing the pole star image in the field and making the settings of the eye-piece Nicol for the four positions of equal brightness, and the other bringing the other star into the field by the other prism and reading off and recording the observer's settings of the eye-piece. At the beginning, middle, and end of each continuous series of observations the prism of the south objective was also turned to the pole star, and the two images of this were compared, in order to furnish the corrections necessary on account of unequal transparency and reflecting power of the two objectives and prisms.

In the preliminary chapters of the work are given the details of the various methods employed to discover and eliminate all sources of systematic error, and their completeness and thoroughness assure the professional astronomer of the high degree of confidence which can be placed in the results. Only a few of the most interesting points can be noted here, and those very briefly. The discussion of a long series of observations upon a list of 100 circumpolar stars, at upper and lower culminations, gives for the co-efficient of atmospheric absorption:

$0.25 \times$ secant of the zenith distance, *i. e.*, a star seen from the outside of our atmosphere would appear a quarter of a magnitude brighter than it does now in the zenith, and half a magnitude brighter than at 60° from the zenith. The magnitudes given in the final catalogue are all reduced to what they would appear if the star were seen in the zenith. It would be interesting to see some careful determination of the atmospheric absorption made within the last year, for, in the opinion of many observers, the transparency of the atmosphere and the brightness of all the stars have sensibly diminished ever since the red sunset phenomena following the Krakatoa explosion in August, 1883, and by not a few all these effects, and the still continuing dirty pinkish red corona around the sun, are attributed to Krakatoa dust still overhead, though now at a considerably lower level than at first.

In all this work the constancy of brightness of the pole star was of course a much-to-be-desired condition, and this question received very careful investigation, and there seems to be no doubt of its reality so far as photometric measurements can determine. Besides the use of the long series of observations upon the 100 circumpolars, a special series of naked-eye comparisons of *Polaris*, with several neighboring stars of nearly equal brightness, was undertaken for this purpose, and in connection with the latter some very interesting results come out, showing that there is in the case of some observers a very decided difference (and very likely to some extent with all) in the apparent relative brightness of two stars depending upon their relative positions right and left and up and down. This had been shown in the photometric work, so that in each comparison the two images in the field of the photometer were reversed right and left between the two pairs of settings of the Nicol. It is interesting to find that it also affects naked-eye estimates, in spite of the fact that in the latter the endeavor is to look steadily at one star and then at the other alternately.

The most important question of all is the scale of magnitudes adopted. Professor Pickering has adopted that proposed some years ago by Pogson, the director of the Madras Observatory.

On this scale, then, we receive from a sixth-magnitude star, which is about the limit of naked-eye vision, just one-hundredth part as much light as from a first-magnitude (about one-fortieth that of a second, one-sixteenth that of a third, three-nineteenths that of a fourth, and two-fifths that of a fifth-magnitude star). This is the first time that the magnitudes of the stars have been measured and catalogued on any such extensive plan or with any such degree of accuracy, and at the same time upon a true geometrical light-ratio scale, and it marks an epoch and an entirely new starting point in stellar photometry. Hitherto there has been much confusion in this matter, although a pretty general adoption of Argelander's scales of magnitudes has been slowly mending this. But the work of Professor Pickering must inevitably, from its intrinsic merit, at once replace all existing scales of magni-

tudes; and, besides, it furnishes the first available data for a rigorous comparison and reduction of all previous catalogues to a common truly photometric scale. Many interesting results of these comparisons are promised in part II, some of which were outlined by Professor Pickering at the September meeting of the American Association. The bulk of the volume is taken up with chapter V, which contains the general catalogue and its accompanying explanations. This has been more recently issued separately, under the name of the *Harvard Protometry*, and it should be in the hands of every professional and amateur astronomer at once the world over. In it is condensed in remarkably convenient form a vast mass of detailed information. Beside the results of the Harvard photometric work with the number of observations and the resulting probable error of the mean, are given the results of a series of eye estimates undertaken specially to compare the two methods. In columns alongside are the corresponding magnitudes in the four principal standard catalogues of magnitudes, the *Uranometria Nova* of Argelander, the *Atlas Coelestis* of Heis, the *Durchmusterung* of Argelander, and the *Uranometria Argentina* of Gould. On the right-hand page are the differences of magnitude between the *Harvard Protometry* and fourteen other catalogues of eye estimates, and the three photometric catalogues of Seidel, Wolff, and C. S. Peirce, for the comparatively small number of stars contained in these last; also a column devoted to the colors of the stars so estimated by Mr. W. S. Franks, of the English Royal Astronomical Society, in a special series of observations for that purpose. Columns of reference numbers to the original series for each observation, and also the residual of each from the mean, are given in every case, so that the whole results lie open at a glance all in one place. In printing these residuals, a novel use of type is made, the negative ones being in italics, thus saving the space of plus and minus signs and giving a much better appearance. Where the residual is greater than nine and less than twenty, only the right-hand figure is printed, but in heavy-faced type. The volume is from the Cambridge University Press of John Wilson & Son, and is throughout, especially in the tables and the catalogue, a beautiful piece of typographical work.

PHOTOGRAPHY AS A MEANS OF CHARTING STARS.

In a recent communication to the Paris Academy of Sciences, Admiral Mouchez, director of the Paris Observatory, states that MM. Henry, finding it almost impossible, on account of the great number of stars, to chart the part of the heavens which they have now reached by the methods heretofore adopted, have had recourse to photography. Their first attempt with a provisional apparatus has been so successful that Admiral Mouchez considers that the problem will soon be solved. Proofs of plates taken with a telescope $0^m.16$ in diameter and $2^m.10$ focal

length, corrected for the photographic rays, were submitted to the meeting. Each plate contains a part of the sky extending 2° in R. A. by 3° in Dec., and contains about 1,500 stars from the 6th to the 12th magnitude, *i. e.*, to the limit of visibility of an instrument of the size used. The results have induced MM. Henry to undertake the construction of a powerful instrument for this class of work, and they are now engaged in constructing an object-glass of $0^{m}.34$ diameter, which will be corrected for the photographic rays and so constructed as to cover clearly and without distortion the greatest possible space. In reference to the advantages of this method of charting, Admiral Mouchez points out that work which ordinarily takes several months to perform can be done in a single hour. It is considered that with the new apparatus stars to the 13th or even 14th magnitude will probably be secured. (*The Observatory*, October, 1884.)

Photographic maps of stars.—A catalogue of the magnitudes of 500 stars situated in the constellations *Auriga*, *Gemini*, and *Leo Minor*, has been determined by the Rev. T. E. Espin from photographs taken with the equatorial stellar camera at the observatory of the Liverpool Astronomical Society. The magnitudes are compared with those given in Argelander's *Durchmusterung*, with which, in the large majority of cases, they agree remarkably well. "There can be no doubt," says Mr. Espin (in the *Observatory* for September), "that the photographic impression is nearly equal to the eye magnitude in the case of two-thirds of the stars. The other third fall into one of two classes: the bluish stars increase in magnitude, while the reddish ones decrease." No positive evidence of fluctuations of stellar light has been obtained; in fact, of the 500 stars whose magnitudes have been reduced from the plates, only two cases of possible variation have been detected. Attempts have also been made to photograph various star clusters and nebulæ. The results are very promising, but much improvement is to be looked for in the practical working and reduction of the plates. (*Athenæum.*)

COMETS, METEORS, ZODIACAL LIGHT, ETC.

Statistics of cometic orbits.—Dr. Paul Lehmann, of Berlin, has reprinted a compilation with the above title, which contains much interesting information in a tabular form. Two hundred and ninety-four cometic orbits are more or less well known. Of these 221 have parabolic orbits, and of the elliptic orbits

7 have a period from 10,000 to 50,000 years;
23 have a period from 1,000 to 10,000 years;
6 have a period from 500 to 1,000 years;
9 have a period from 100 to 500 years;
6 have a period from 50 to 100 years;
5 have a period from 10 to 50 years;
17 have a period from — to 10 years.

All the comets whose periods are under 10 years have *direct* motion,

and of the 28 comets whose periods are under 100 years, only 3 have retrograde motion.

An interesting table of comets with similar orbits, which are yet not identical, is also given, and further a table of those comets which are related to each other in groups, so that all their orbits intersect in a line. These comets may be supposed to have had a common origin.

Definitive determination of comet orbits.—For many years Dr. Bruhns kept a general outlook over the matter of the definitive determination of comet orbits, and his annual papers in the *V. J. S. der Astron. Gesell.* were of great value in directing attention to the cases of comets whose orbits needed attention, in indicating the sources from which observations could be taken, and by preventing unnecessary duplication of such work through correspondence. Dr. Weiss, director of the Vienna Observatory, has now agreed to fill the same place, and those intending to occupy themselves with this branch of computation will do well to address themselves to him.

Periodic comets.—Several periodical comets are expected to return to perihelion in 1885. That of Olbers, discovered on the 6th of March, 1815, has been calculated to have a period of somewhat more than seventy years, and will, therefore, probably appear again either in 1885 or 1886. Encke's comet was first discovered in 1786, but its periodicity was not detected till 1819, since which time it has been observed at every return, at intervals of about three and a third years. It will once more be in perihelion on the 7th of March, 1885. A comet discovered by Herr Tempel on the 3d of April, 1867, was found to be moving in an elliptic orbit with a period of about six years; it was observed in 1873 and in 1879, and another return is expected to take place in April of the present year. Another comet of short period was discovered by the same astronomer on the 27th of November, 1869, but its periodicity was not recognized until after it had been rediscovered by Mr. Swift, at Rochester, N. Y., in 1880, in consequence of which it is usual to call it Swift's comet. The period is about five and a half years, so that another return to perihelion will be due about the end of this year; but like that which must have taken place in 1875, it is likely to pass unseen, the comet being unfavorably placed for observation. Tuttle's comet occupies a position of its own in having a period amounting to about thirteen and a half years. It was first discovered by Méchain, at Paris, on the 9th of January, 1790, but its periodicity was not detected until after the second discovery by Mr. Tuttle, at Cambridge, United States, on the 4th of January, 1858, when it was found that it must have made four unobserved returns since Méchain's discovery. It was observed again in the autumn of 1871, passing its perihelion at the end of November, and another return will be due in the month of July, 1885. (*Athenæum.*)

Comet 1867, *II.*—M. Raoul Gautier, of Geneva, has been investigating the perturbations produced by the action of the planets *Jupiter*, *Saturn*,

and *Mars* upon the motions of the first periodical comet (II, 1867) of Tempel. The perihelion passage in the year of discovery took place on the 24th of May; those on the two subsequent returns (both of which were observed) on the 10th of May, 1873, and the 7th of May, 1879, respectively; but M. Gautier finds that the effect of the disturbances will be to delay the return to perihelion this year until the end of June or the beginning of July. The comet diminished in brightness at each successive return, and is likely on this occasion to be even fainter than in 1879. M. Gautier has published an ephemeris sufficiently accurate to enable astronomers to find the comet when it makes its nearest approach to the earth. It was first discovered on the 3d of April, 1867.

Brorsen's comet of short period.—We have not yet met with any intimation that an ephemeris of this comet for the approaching reappearance is being prepared; that for the last return, in 1879, was furnished by Prof. L. R. Schulze, of Dobeln; the time of perihelion passage was about eleven hours later than his calculation gave it. Disregarding perturbation, the comet would be again due at perihelion in the middle of September next, in which case it would be observable in the two hours before sunrise, in August and September, under somewhat similar conditions to those in 1873. Supposing the perihelion passage to occur September 14.5, the comet's position at that time would be in about R. A. 154°.5 and N. P. D. 76°.2, the distance from the earth 1.41.

Since the discovery of this comet within one day of perihelion passage in 1846 it has been observed at four returns, viz, in 1857, 1868, 1873, and 1879. (*Nature.*)

The great comet of 1882.—Professor Howe, of Denver, Colo., notifies that he has undertaken a definite determination of the orbit of this comet, which will doubtless be a work of some labor. Thus far calculation appears to indicate that the comet was moving in an ellipse, with a period not differing much from eight centuries; Kreutz gave 843, Fabritius 823, Frisby 794, and Morrison 712 years; the orbit of Fabritius depends upon the widest extent of observation. Between the earliest and latest accurate positions the comet described an orbital arc of 340°.

Those who may have unpublished observations of position of the great comet of 1882 will do well to communicate them to Professor Howe forthwith. (*Nature.*)

The great comet of 1882.—In an appendix to the *Washington Observations*, 1880, is an account prepared by Mr. W. C. Winlock, on the great comet of 1882 as observed at Washington, first with the 9.6-inch and subsequently with the 26-inch refractor. The latest date on which the comet's position was determined is April 4, 1883. Micrometrical measures of the nucleus were made on a number of evenings, and from a plate showing its aspect and formation between February 1 and March 3 the difficulty of deciding upon the proper point for observations of position, owing to the existence of several almost equally luminous condensations

in the head of the comet, is very apparent. For a similar reason, in another plate the points observed with the transit-circle from September 19 to March 3 are shown. There has rarely, if ever, existed a greater need for precautions of this nature, to assist in the combination of the places obtained at various observatories for the accurate determination of the orbit. (*Nature.*)

Comets of 1884:——

Comet 1884 I	= Comet (*b*) 1883.
	= Pons-Brooks's comet.
	= Pons's comet, 1812.
	= 1812 comet.
Comet 1884 II	= Comet (*b*) 1884.
	= Barnard's comet.
Comet 1884 (Wolf)	= Comet (*c*) 1884.
[Comet 1884 Spitaler, May 26.]	(Possibly a return of Comet 1858 III. Lost after discovery. No accurate observations obtained.)

A new comet of short period.—M. Schulhof, of Paris, has lately ascertained that the observations of the third comet of 1858 (a very limited number) are closely represented by an elliptical orbit with a period of about six years and a half.

Comet c, 1884.—When the observations of the comet (*c*, 1884) which was discovered by Herr Wolf at Heidelberg on the 17th of September had been carried on for a few weeks it became apparent that they could no longer be represented by a parabola, but that the comet was moving in an ellipse of short period. Its elements have been computed by Professor Krüger, of Kiel, and by Dr. Zelbr, of Vienna, the former making the period about 2,391, and the latter about 2,470 days; that is, somewhat more than six years and a half.

Prof. H. C. Wilson, astronomer in charge of the Cincinnati Observatory, has issued the seventh publication of the observatory, which contains the observations of the comets of 1880, 1881, and 1882, made under the direction of Prof. Ormond Stone until June, 1882. Since that time the work has been carried forward by himself.

Besides the ordinary observations for positions, interesting physical studies of the comets for the three years named are also presented. The method used in reducing and discussing observations of the trains of comets is that of Professor Bredichin, director of the Observatory of Moscow. For reduction to the plane of the orbit formulæ found in A. N. Nos. 300 and 1172 were used. This publication also contains ten full-page drawings, showing interesting physical changes in nuclei and tails of *b* 1881, *a* and *c* of 1882. The notes that precede these drawings are instructive, for they indicate how the new physical theories of Professor Bredichin stand the test in relation to these comets.

The zodiacal light.—The current volume of the *Proceedings of the*

American Academy of Arts and Sciences contains a very valuable paper by Mr. A. Searle on the zodiacal light, in which he has collected and reduced on a uniform system the evening observations of the principal observers of the zodiacal light. The points taken up are the approximate position of the zodiacal cone in the visible hemisphere of the sky, the elongation of the vertex, and the latitudes of the northern and southern boundaries at successive elongations 30° apart. The details of more than 650 observations by Jones, Heis, Schmidt, and others are exhibited in tabular form, whilst their results are conveniently and completely summarized in a number of other tables showing the monthly means, and means for different series.

Mr. Searle supports Jones's view that the apparent changes in the place of the light should be referred rather to the corresponding changes in the place of the ecliptic in the visible hemisphere than to the geographical position of the observer in latitude, and regards it as probable that atmospheric absorption is an important and, perhaps, the only cause of the variations of the zodiacal light in latitude. But "if atmospheric absorption has the importance here assigned to it, in the study of the zodiacal light, we cannot expect to determine the true position of the light on any occasion by the simple methods heretofore in use." Direct photometric observations must be made, or, failing these, observers "must compare together different portions of the light and also specified portions of the light and of the Milky Way." And the Milky Way must itself be studied in a similar systematic manner. A careful photometric inquiry "is indispensable if we are to substitute definite knowledge for the vague information now before us with regard to 'zodiacal bands,' the singular phenomenon of the 'Gegenschein,' and the possibly periodic variations in the main body of the zodiacal light, as well as its apparent changes from hour to hour."

In dealing with this question of the photometric observation of the light, Mr. Searle mentions the interesting fact that from Celoria's and Sir W. Herschel's observations the Milky Way would appear to be about two magnitudes brighter than the mean brightness of the sky. On this estimate the brighter parts of the zodiacal light would be commonly three or four magnitudes brighter than the surrounding sky.

Mr. Searle remarks in conclusion: "It is not my intention, on this occasion, to discuss the probability of any explanation of the zodiacal light; I have merely to remark with regard to the ordinary meteoric theory, that it gains greatly in simplicity if we dispense with all the imaginary meteoric bodies or rings with which it has usually been connected and retain merely the conception of meteoric dust diffused throughout the solar system. It may be shown mathematically, if we regard the meteoric particles as solids reflecting light irregularly, that an appearance like the zodiacal cone with an indefinite vertex would result." (*The Observatory, September*, 1884, *page* 265.)

THE SUN.

Solar eclipses.—An interesting investigation respecting two ancient eclipses was communicated by Herr Bernhard Schwarz to the Vienna Academy last April. The first of these eclipses is one referred to in a fragment of Archilochus preserved by Stobæus (*Florilegium ex.* 10).

Professor von Oppolzer had already called attention to this passage, and suggested that it probably referred to a solar eclipse which occurred on the 6th of April, B. C. 648, in ordinary or historical chronology (647 in scientific chronology). Herr Schwarz has made a very careful calculation of all the solar eclipses which took place during the life-time of Archilochus, between the years B. C. 700 and 640. He finds that the only choice lies between an eclipse which was annular in the Grecian Archipelago in the afternoon of June 27, B. C. 661, and the above, which was total in the morning of April 6, B. C. 648. The probability is that the eclipse of 648 is the one mentioned by the poet.

The other eclipse discussed by Herr Schwarz is mentioned in an Assyrian inscription of Asurbanipal, to which attention was directed by Dr. Jacob Krall. The inscription may be thus translated: "In the month Tammuz an eclipse took place of the Lord of Day, the god of light. The setting sun thereupon left off shining, and I in like manner put off beginning the war against Elam during [here a gap in the text] days." Taking into account all the circumstances here mentioned, there can scarcely be a doubt that the eclipse referred to was the earlier of the two before mentioned (June 27, B. C. 661), which, annular in the Grecian Archipelago, was visible as a large partial eclipse a little before sunset in Assyria and Persia. (*Athenæum.*)

Transit of Venus, 1882.—On the occasion of the transit of *Venus* of 1882 the commission of the Belgian Government, under the direction Dr. J. C. Houzeau, placed its chief reliance upon observations made with a new form of heliometer, in which, by employing half objectives of unequal focal length, the images of the *Sun* and *Venus* were nearly equal, allowing an observation of the angular distance of the centers of these two bodies to be taken by a single measure. With instruments of this pattern, set up in the southern hemisphere at Santiago de Chili, and in the northern at San Antonio, Tex., a sufficiently large number of measures were made to afford a fair test of the worth of the new method. The facility with which this instrument can be employed in work of precision is shown well enough by the large number of observations obtained at the Santiago station, where no clouds interfered with the progress of the measurements. Doctor Houzeau has completed the discussion of the work of the two expeditions, and the results are published as the first fascicule of the fifth volume of the *Annales de l'Observatoire Royale de Bruxelles.* The value of the solar parallax which he derives is 8″.911, or about one-tenth of a second larger than that now regarded as the true value.

Sun-spots.—"Report to the Solar Physics Committee on a Comparison between Apparent Inequalities of Short Period in Sun-spot Areas and in Diurnal Temperature Ranges at Toronto and at Kew." By Balfour Stewart, M. A., LL.D., F. R. S., and William Lant Carpenter, B. A., B. Sc. Communicated to the Royal Society at the request of the solar physics committee.

It has been known for some time that there is a close connection between the inequalities in the state of the sun's surface as denoted by sun-spot areas and those in terrestrial magnetism as denoted by the diurnal ranges of oscillation of the declination magnet; and moreover the observations of various meteorologists have induced us to suspect that there may likewise be a connection between solar inequalities and those in terrestrial meteorology.

This latter connection, however (assuming it to exist), is not so well established as the former, at least if we compare together inequalities of long period. It has been attempted to explain this by imagining that for long periods the state of the atmosphere as regards absorption may change in such a manner as to cloak or diminish the effects of solar variation by increasing absorption when the sun is strongest, and diminishing absorption when the sun is weakest.

On this account it seemed desirable to the authors to make a comparison of this kind between short-period inequalities, since for these the length of period could not so easily be deemed sufficient to produce a great alteration of the above nature in the state of the atmosphere.

The meteorological element selected for comparison with sun-spots was the diurnal range of atmospheric temperature, an element which presents in its variations a very strong analogy to diurnal declination ranges.

It is such a comparison that the authors have made, their method of analysis being one which enables them to detect the existence of unknown inequalities having apparent periodicity in a mass of observations. A description of this method has already been published in the *Proceedings of the Royal Society* for May 15, 1879. The comparison was made by this method between sun-spot observations extending from 1832 to 1867, inclusive, Toronto temperature-range observations extending from 1844 to 1879, inclusive, and Kew temperature-range observations extending from 1856 to 1879, inclusive. The following conclusions were obtained from this comparison:

1. Sun-spot inequalities around twenty-four and twenty-six days, whether apparent or real, seem to have periods very nearly the same as those of terrestrial meteorological inequalities as exhibited by the daily temperature-ranges at Toronto and at Kew.

2. While the sun-spots and the Kew temperature-range inequalities present evidence of a single oscillation, the corresponding Toronto temperature-range inequalities present evidence of a double oscillation.

3. Setting the celestial and terrestrial members of each individual

inequality, so as to start together from the same absolute time, it is found that the solar maximum occurs about eight or nine days after one of the Toronto maxima, and the Kew temperature-range maximum about seven days after the same Toronto maximum.

4. The proportional oscillation exhibited by the temperature-range inequalities is much less than the proportional oscillation exhibited by the corresponding solar inequalities. (*Nature.*)

Variations in the Sun's diameter.—A pamphlet of 17 pages by Dr. Hilfícker, of the Observatory of Neuchatel, treats the 3,468 observations of the *Sun* made by eight observers during the years 1862–'83, with the object of determining whether the *Sun's* diameter varies. The meridian circle has an aperture of 115^{mm}, and a magnifying power of 200 is used, and each limb of the Sun is observed on 13 threads, so that these observations are more suitable for the purpose than many other series which have been used for the purpose. Besides the Neuchatel series, others are quoted, though several papers on the subject are not referred to.

Dr. Hilficker gives two conclusions, which he regards as satisfactorily proved by his discussion. These are (1) that the variations in the diameter of the *Sun* shown by the Neuchatel observations are real; (2) that these changes depend upon the period of the solar spots; that is, that the largest diameters co-exist with the minimum Sun-spots, and *vice versa.*

It will be noticed that this conclusion does not agree with those of other discussions, notably with the very satisfactory one of Dr. Auwers, based on the results of the observations of seven observatories, or with the discussion of corresponding observations at Greenwich and Washington, by Professors Newcomb and Holden.

The Moon.—Dr. Th. von Oppolzer, of Vienna, has lately published an attempt to explain the discrepancy between the observed value of the secular acceleration of the moon's mean motion and that derived from the mathematical theory by Delaunay and Adams. This difference has heretofore been supposed to be accounted for by the continued retarding action of the tides on the rotational velocity of the earth; but Professor Oppolzer, accepting the now generally believed pervasion of interplanetary space by comminuted cosmical matter, proceeds to estimate the threefold action of such matter on the motions of moon and earth. First, the masses of both bodies are continually receiving slight increments from the accumulation of this dust upon their surfaces. Second, a part of this increment of the moon's mass acts in such a way as to decrease its tangential volocity. Third, the continued deposition of cosmical dust on the surface of the earth changes its rotational velocity, affecting thus the apparent motion of the moon. All these effects are reduced to numbers, in the form of co-efficients of terms in the moon's mean longitude multiplied by the square of the time, and by an unknown quantity which represents the thickness of a layer of cosmical dust which falls on the surface of the earth in a century. If this latter

be supposed to be 2.8 millimeters, the entire discrepancy in the secular acceleration of the moon's motion disappears. And on the same hypothesis, the density of the medium surrounding the earth and moon is equivalent to the density of air divided by 3,760,000,000,000. Dr. von Oppolzer's paper will be found entire in No. 2573 of the *Astronomische Nachrichten*. (*The Nation.*)

THE PLANETS.

Mercury.—Denning, in a recent number of the *Observatory*, gives an account of certain markings detected by himself upon the surface of *Mercury*, in November, 1883, from which he deduces a rotation period of about twenty-five hours. The value given in our text-books, and provisionally accepted, though with much reserve, is twenty-four hours five minutes, depending upon certain observations of Schroeter and Harding, at Lilienthal, early in the century. Schiaparelli, also, has observed markings on the planet several times during the past two years, and says that "the rotation period, as usually adopted, is not exact; in fact, is very far from the truth"; but he does not say whether he finds the period greater or less than that assigned by Schroeter. A memoir upon the planet *Mercury* is expected soon to appear from his pen, and will probably add considerably to our present knowledge of the planet.

*The photometry of Saturn's ring.**—In his paper, Professor Seeliger enters into some investigations with the view of pointing out the knowledge that he thinks may be obtained with regard to the construction of *Saturn's* ring by means of photometrical observations of the amount of light reflected from it at different times. Were the ring a body of continuous surface, the apparent intensity of its illumination would (unless, indeed, assumptions were made of an altogether improbable kind as to its structure) be very different in different relative positions of the *Sun* as well as the earth. Changes of this nature are not, as a matter of fact, indicated by observation, the apparent brightness of the ring being always nearly the same, and the amount of light received from it would seem to depend entirely upon the proportion of the whole surface which is turned toward the earth, or upon the angle of elevation of the earth above the plane of the ring. Hence Zöllner concluded that Lambert's law of photometry was not applicable to this case. But Professor Seeliger shows that, under certain plausible assumptions, the observed effects are consistent with that law, the extent of application of which can hardly, he thinks, be overestimated. Maxwell pointed out, twenty-five years ago, from purely mechanical considerations, that the ring could not be a compact solid or fluid mass, but must consist of a number of separate discrete particles similar to those which compose a meteoric stream. On this supposition, the observed photometric conditions admit of a simple explanation, though their full significance cannot be worked out until more accurate observations have been made with regard to the variation in intensity of the light of the ring at dif-

* Astron. Nachr., No. 2612.

ferent times. Professor Seeliger's hope is that the investigations and considerations brought forward by him, in the paper before us, may have the effect of interesting photometric observers in the subject, and inducing them to devote more attention to it than has yet been done. (*The Observatory, October*, 1884.)

Mass of Saturn.—From 128 observations of *Japetus* in 1875, 1876, and 1877, Prof. A. Hall has determined the mean distance of this satellite with a very small accidental error. The periodic time has been determined by a comparison with observations by the Herschels. The resulting mass of *Saturn* is $\frac{1}{3482.2}$. This is materially larger than the masses deduced by Bessel (from *Titan*) and Le Verrier (from perturbations).

The figure of the planet Uranus.—Dr. Seeliger, director of the Munich Observatory, has employed the $10\frac{1}{2}$-inch refractor (which has been remounted by the Repsolds) in measures of the disks of the various planets. He employs a total reflecting prism back of the eye-piece, and can therefore cause any diameter of the planet to appear at any angle with the vertical.

Measures of this kind have been made (on ten nights) on *Uranus*, and Dr. Seeliger's result is clearly against any ellipticity of the disk.

In this he disagrees with several late observers (Schiaparelli, Young, and others), but agrees with the conclusions of Lassell, Bruhns, Engelman, and others. The question is not settled, in any event, but this latest result is interesting specially on account of the method employed, which avoids a dangerous kind of constant error.

The aspect of Uranus.—At the sitting of the Academy of Sciences of Paris on April 21, M. Perrotin presented a note on the aspect of *Uranus*, from observations made with the 15-inch equatorial at the Observatory of Nice. On March 18 he had remarked, in company with Mr. Lockyer, a bright spot near the lower limb of the planet, as seen in the inverting telescope. Further observations showed that it was near the equator of *Uranus*. It was a very difficult object, and much uncertainty existed as to its exact position; it was better seen as it approached the limb. It was observed on April 1 about 11^h, at the northern extremity of the equatorial diameter, and on the next night about $10^h\ 40^m$, at the southern extremity; it occupied the same position on April 7 at $10^h\ 30^m$, and April 12 at 11^h. These observations, M. Perrotin adds, made at the limits of visibility, required very favorable conditions, and being aware of the possibility of illusion in such a case, he invites the attention of observers possessed of powerful optical means, in order to control his own impressions. The appearance and the indeterminateness in the duration of the phenomenon on April 1, when the images were best, rather point to a luminous belt than to a single spot, which introduces uncertainty in the times of the observations; with due regard to this, M. Perrotin finds a fair agreement with the assumption of a rotation not differing much from ten hours. On April 12 Mr. Trépied was present, and confirmed the impressions received by the Nice astronomer; he also

remarked in the bright part a condensation which had previously escaped notice.

By "diamètre equatorial" we presume M. Perrotin refers to the diameter in the plane of the orbits of the satellites.

Uranus.—In a note communicated to the Academy of Sciences, Paris, on June 9, MM. Henry stated that, observing on very fine nights with the 15-inch refractor, they have satisfied themselves of the existence of two gray belts, straight and parallel, and placed almost symmetrically with respect to the center of the disk of *Uranus*, and that, by measures of their direction, they have found an inclination of about 41° to the orbits of the satellites; they assume that the planet's equator is in the direction of the belts.

THE MINOR PLANETS.

That part of the *Berliner Astronomisches Jahrbuch* for 1887 containing its specialty, the ephemerides of the small planets for 1885, has been issued in advance of the publication of the volume. There are approximate places for every twentieth day of 237 out of the 244 now known, with accurately calculated opposition ephemerides of 19. The most reliable elements of the orbits of these bodies to No. 237, inclusive, are appended. *Aethra* continues at a distance of less than 1.0 from the earth until February 11, and if the orbit had been more closely determined, would have afforded a favorable opportunity of applying the method of finding the solar parallax suggested by Professor Galle, as the planet has been a 9th magnitude at this apposition. *Eva*, *Stephenia*, and *Agathe* also approach the earth during the present year, within her mean distance from the sun; on August 10 *Stephenia* will be at a distance of only 0.76, magnitude 11½.

Æthra has the least perihelion distance of the group, 1.604, while *Andromache*, with considerable eccentricity, has the greatest aphelion distance, 4.726; so that the orbits of 244 planets extend over a space of 3.122, the earth's mean distance from the being taken as unity. The longest period of revolution occurs in the case of *Hilda;* it is yet doubtful which has the shortest period; No. 149, *Medusa*, is credited with it at present, but until his member of the group has been reobserved the point is perhaps doubtful. The most recently detected planet appears to have the shortest revolution next to *Medusa* judging from the elements in the last circular of the *Berliner Jahrbuch.* (*Nature.*)

Asteroids discovered in 1884.

No.	Name.	Discovered by—	Date.
236	Honoria	Palisa	Apr. 26
237	Hypatia	Palisa	June 27
238		Knorre	July [illegible]
239		Palisa	Aug. [illegible]8
240	Vanadis	Borelly	Aug. 27
241	Germania	Luther	Sept. 12
242	Kriemhild	Palisa	Sept. 22
243		Palisa	Sept. 29
244		Palisa	Oct. 14

INTERNATIONAL MERIDIAN CONFERENCE.

The full text of the final act of the International Meridian Conference is given below, extracted from the official publications.

The President of the United States of America, in pursuance of a special provision of Congress, having extended to the Governments of all nations in diplomatic relations with his own an invitation to send delegates to meet delegates from the United States, in the city of Washington, on the first of October, 1884, for the purpose of discussing, and, if possible, fixing upon a meridian proper to be employed as a common zero of longitude and standard of time-reckoning throughout the whole world, this International Meridian Conference assembled at the time and place designated; and, after careful and patient discussion, has passed the following resolutions:

1. "That it is the opinion of this Congress that it is desirable to adopt a single prime meridian for all nations, in place of the multiplicity of initial meridians which now exist."

2. "That the Conference proposes to the Governments here represented the adoption of the meridian passing through the center of the transit instrument at the Observatory of Greenwich as the initial meridian for longitude."

3. "That from this meridian, longitude shall be counted in two directions up to 180 degrees, east longitude being plus and west longitude minus."

4. "That the Conference proposes the adoption of a universal day for all purposes for which it may be found convenient, and which shall not interfere with the use of local or other standard time, where desirable."

5. "That this universal day is to be a mean solar day; is to begin for all the world at the moment of mean midnight of the initial meridian, coinciding with the beginning of the civil day and date of that meridian; and is to be counted from zero up to twenty-four hours."

6. "That the Conference expresses the hope that as soon as may be practicable the astronomical and nautical days will be arranged everywhere to begin at mean midnight."

7. "That the Conference expresses the hope that the technical studies designed to regulate and extend the application of the decimal system to the division of angular space and of time shall be resumed, so as to permit the extension of this application to all cases in which it presents real advantages."

The action in the various countries upon these propositions, so far as it is known, is as follows. It should, however, be premised that no one of the Governments concerned has yet notified its decisions and that the action taken is, in a sense, unofficial:

England.—The Astronomer Royal has ordered that the universal day be adopted within the observatory at Greenwich. And the public clock at the gate in Greenwich Park has been set to the new time, *i. e.*, back

12h. As an experiment, a small almanac is published in *Nature* in the new time. Nothing has been said of any change in the *Nautical Almanac.*

France.—No official action has been taken, and there is no prospect that the universal day will be adopted either in the National Observatory or in the computations of the *Connaissance des Temps.*

Germany.—Professors Foerster, Auwers, and Tietjen have declared against the universal day on principle, and have announced that the *Berliner Jahrbuch* will not adopt it. Professor Krueger, the editor of the *Astronomische Nachrichten*, is understood to oppose any such change as contemplated.

United States.—The policy of the officials of the United States has been vacillating, but the final decision is to adhere to the present mode of reckoning. According to an official publication of the Superintendent of the Naval Observatory, the opinion among American astronomers is against the change. The superintendent of the *American Ephemeris* has practically announced that no change will be made in the Ephemeris before 1900 A. D.

A consideration of the above statements leads to the conclusion that the net result of the Conference has been the adoption of the meridian of Greenwich as a prime meridian from which to measure longitudes.

In this connection it may be of interest to record that the United States has legalized the use of "Eastern Time" (the local solar time of the 75th meridian W. from Greenwich) in Washington, etc., and that the State of Connecticut has adopted this time as standard within the State.

The mean solar time of the 90th meridian, "Central Time," has been made the legal time within the State of Wisconsin.

REPORTS OF OBSERVATORIES, ETC.

The article "Observatory" in the ninth edition of the *Encyclopædia Britannica* is from the pen of Dr. J. L. E. Dreyer, director of Armagh Observatory, and formerly editor of *Copernicus.* The article commences with a brief introduction giving an outline of the development of observatories, from the days of Hipparchus to the present time. A gazetteer of the principal existing observatories follows, in which is given a description of the equipment and work of each, as full as space permits. A number of English private observatories, now discontinued, are also described, on account of their historical interest and the important work which has been performed at many of them. (*The Observatory, September*, 1884.)

Reports of English Observatories.—From the *Monthly Notices*, R. A. S., the following short notices of the activity of English observatories are condensed:

Armagh.—A permanent fund of $10,000 is provided, whose income helps to support the Observatory. A 10-inch Grubb refractor is in process of construction. The new Armagh catalogue is in the press.

Dr. Dreyer has printed (for private circulation) an historical account of the Armagh Observatory in a pamphlet of twenty pages. The frontispiece gives an autotype picture of the buildings. This account is of much interest, since the history of the observatory extends from 1791 to now.

Cambridge.—Three thousand one hundred and twenty five meridian observations have been made, 2,433 of which relate to zone stars between 25° and 30°. Division errors have been investigated.

Dunsink.—The meridian circle is used to observe stars between 2° and 23° south declination. It is not stated what list is under observation. It appears that the observations are not differential in declination since the Nadir gives the zero of declination.

Edinburgh.—Is pressing upon the Government the printing of the remaining volumes of its star catalogue.

Glasgow.—Is observing a list of proper motion stars.

Kew.—Continues drawings of solar spots, and testing of sextants, watches, and meteorological instruments, etc.

Liverpool.—Continues its work on the effect of temperature on chronometers.

The Oxford University Observatory.—The professor of astronomy has issued his annual report to the board of visitors of the University Observatory. The attendance of students at the lectures has been greater than at any previous time, and the professor mentions "the phenomenon" of the regular appearance of two ladies at his lectures on the planetary and lunar theories, at the same time reminding the board what even the approximate mastery of such theory implies.

On the astronomical work of the staff of the institution during the year, Professor Pritchard's report is a most favorable one. He refers to three memoirs on important astronomical questions which have issued therefrom, and which have been printed in the *Memoirs* of the Royal Astronomical Society. These include an extensive memoir by himself on the "Photometric Determination of the Relative Brightness of the Brighter Stars North of the Equator," in which his work at Cairo is brought to bear, and a memoir by the first assistant, Mr. W. E. Plummer, on the probable motion of the solar system in space, the data for which depend upon Mr. Stone's recent catalogue of southern stars; it is a memoir very similar in character to the well-known one by the late Mr. Galloway. Further, Professor Pritchard has communicated to the Royal Astronomical Society a paper, which was read at the last meeting, demonstrating, as he thinks, the existence of small displacements among the *Pleiades*. Upwards of a thousand measures of the relative brightness of stars were made, leaving about the same number to be made in the next year. This measurement of all the naked eye stars from the pole to the equator will furnish a *Uranometria Nova Oxoniensis*, and Professor Pritchard hopes that its publication may be undertaken by the University Press. The measures of the *Pleiades* having been com

pleted, he now intends to devote himself to lunar work—the determination of selenographical longitude and latitude of a large number of points on the *moon's* surface by means of a valuable series of lunar photographs at the observatory. Reference is made, in addition to the *Pleiades* work, to the existence of measures of some 250 stars in another cluster made at the observatory a few years since, and to be shortly reduced and published; the particular cluster is not indicated in the report, but presumably may be M. 39 in Cygnus, described by Messier when he observed it in 17?4 as "a star-cluster of 1° diameter." (*Nature.*)

Radcliffe Observatory.—Has made over 3,000 transit circle observations on the sun (103), moon (62), and stars.

Savilian Observatory.—Is completing its photometry of naked-eye stars, and has begun the triangulation of the lunar surface.

Temple Observatory, Rugby.—Measures of double stars are continued.

Stonyhurst College Observatory.—Continues its meteorological work and has made 281 drawings of the whole solar disk on 257 days. Attention is paid to the spectra of sun-spots, and the protuberances are observed.

Leyton Observatory (Mr. Barclay's).—Is about to publish its volume V.

Mr. Common's Observatory.—Is about to erect a 5-foot reflector for photography alone. The glass disk has been on hand since 1883 and seems to be satisfactory.

Lord Crawford's Observatory.—Vol. III is about to be issued.

Mr. Crossley's Observatory.—Has been become possessed of Mr. Common's 3-foot reflector.

Lord Rosse's Observatory.—Has been employed in measures of lunar radiant heat and in drawings of *Jupiter* and *Mars.*

Colonel Tomline's Observatory.—Has observed the comets of the year.

Colonel Tupman's Observatory.—Has just been equipped with an 3¾-inch meridian circle, a 4½-inch refractor, and an 18½-inch reflector.

Cape of Good Hope Observatory.—Its work is elsewhere described.

Hong-Kong Observatory.—Is chiefly meteorological and for time-signals; but will soon possess a 6-inch equatorial.

The *V. J. S. der Astronomischen Gesellschaft* for 1884 contains, as usual, reports from the various European observatories. The following notes are condensed from these reports, and give a connected account of the activity of the various establishments for 1883:

Athens.—The *Sun* was observed on 355 days; the *Moon* had 534 points determined in its topography; *Jupiter* was drawn 63 times.

A memoir on the comet of 1882 is nearly ready for printing; 39,400 comparisons of variable stars were made.

Berlin.—Dr. Becker has left the observatory to take charge of the Gotha Observatory.

The Zone + 20° to + 25° is finished so far as observations are concerned. To determine the influence of the magnitude of the stars on the deduced R. A., the transits of 247 stars were observed on 13 eve-

nings, both with the full objective, and through wire nettings held in front of the objective, so as to reduce their magnitude to a given standard. It was found that faint stars were observed later by $0^s.007$ per magnitude.

It is mentioned in this report that two observers determined the places of 240 stars (using 57 fundamental stars for comparison) in four nights. One observer made the pointings, the other read the microscopes.

Volume V of the *Berlin Observations* will shortly be printed.

The computing bureau has issued the *Berliner Jahrbuch* as usual, as well as the two periodicals, *Circulars* and *Correspondence regarding observations of planets.*

Bonn.—The observatory continues to concentrate its efforts on two great works, the *Zone* 40° —50°, and the southern *Durchmusterung.* In the latter work 114,615+1,161 stars have been observed. The observation and reductions of this work are now completed and the printing of the catalogue is begun.

Brussels.—The catalogue of E. Quetelet is printed from 0^h to 12^h. The labors of the observatory in spherical astronomy, in physical astronomy, and celestial mechanics, as well as in regard to the transit of *Venus*, 1882, are described in the report.

Dresden (private observatory).—Baron v. Englehardt continues at his private observatory the observations of minor planets, of comets, and of nebulæ. Twenty-one planets have been observed 63 times; 3 comets have been observed 43 times; 47 nebulæ have been observed 95 times.

Dusseldorf.—In 1883, 18 planets have been observed 49 times; since 1847, 144 planets have been observed 1,151 times.

Six asteroid orbits are computed yearly.

Frankfort-on-the-Main (private observatory).—Herr Eppstein has made, since 1881, 444 gauges, containing 8,332 stars in 113 positions on 23 nights. In all, about 47,000 stars in 2,426 fields in 774 positions.

Sun-spot observations are also regularly made by Herr Eppstein.

Geneva.—The 10-inch equatorial has been used for observations of nebulæ, double stars, asteroids, and satellites of *Saturn.*

The small equatorial has been used to study the solar prominences.

Gotha.—Dr. E. Becker has lately been appointed to the charge of the Gotha Observatory. The larger part of the report relates to repairs and to changes which have been made in the instruments.

Dr. Becker continues the reductions of the Berlin Zone + 20° to + 25°. The *Moon*, the inferior planets and those Mayer stars not in the *Fundamenta* will be observed on the meridian.

Grignon.—The observatory of the Priory of St. John of Grignon, was founded in 1879, and this report relates to its instrumental equipment and to its observations of sun-spots, planets, and comets.

Hereny (Hungary).—Vol. I of its publications has been distributed. The observations relate to the spectra of fixed stars, of variables, and

of comets, as well as to drawings, etc., of *Jupiter* with meteorological observations.

Kalocsa.—The latitude of the observatory has been accurately determined. The *Sun* is regularly observed. Dr. Braun, the director, has contrived a *trigonometer* with which any spherical triangle can be solved (to about 5′ of arc) with great facility (22 triangles in 10 minutes)

Kiel.—Several additions have been made to the instruments; notably a comet-seeker and a star-spectroscope.

The Chronometer Observatory has been separated from the Kiel Observatory, and constituted a distinct establishment under the charge of Dr. C. F. W. Peters. The Helsingfors-Gotha Zone is now printing. Kiel has been telegraphically connected with one of the longitude stations of the European *Gradmessung.*

The *Astronomische Nachrichten* is regularly published here.

Leipsic.—The changes to the instruments appear to be nearly completed. The observatory has acquired the astro-physical apparatus belonging to the late Professor Zoellner.

The work of observation and reduction of the Zone + 5° to + 10° continues, as well as the reduction of the old Zone +10° to +15°.

Leipsic (private observatory).—Dr. Engelmann made, in 1882, 1,200 observations of 400 double stars; in 1883, 1,600 observations of 510 double stars, as well as other observations.

Victoria and *Sappho* were observed to determine the solar parallax on Dr. Gill's plan.

Observatory at Liège.—The Belgian Government has founded an observatory at Liège for astronomy, meteorology, and magnetism, under the direction of Professor Folie.

Lund.—The Zone observations are finished. Dr. Dunér has measured 80 double stars, 563 spectra of red stars, and 55 wave lengths in star spectra of the III type. *Victoria* and *Sappho* have also been observed by Dr. Engstrom.

Milan.—The 18-inch equatorial is not yet received.*

The 8-inch equatorial has been employed in making (395) observations of double stars, (64) observations of 3 comets, etc.

The most generally interesting work of the observatory is the preparation of Baron Dembowski's observations for the press. They will be printed in two volumes. The contents of vol. I is as follows:

I. 2,100 measures of 611 stars made at Naples.

II. 2,155 measures of 432 stars of Otto Struve's catalogue.

III. 663 measures of 199 stars, whose distance is between 32″ and 120″.

IV. 1,229 measures of 342 doubles, discovered by Burnham.

V. 476 measures of 134 miscellaneous pairs.

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*It is understood that the cost of the dome and telescope is to be paid from a grant of 250,000 francs ($50,000). The objective cost 45,000 francs ($9,000), and is made by Merz. The mounting (by Repsold) cost 65,000 francs ($13,000).

VI. 919 observations of 26 circumpolar pairs.

In all 7,542 measures.

Vol. II will contain 13,800 measures of W. Struve's Dorpat catalogue.

Munich.—The repairs are nearly completed. Among the 37,000 stars whose places have been fixed at Munich, some 9,000 have been only once observed, and are in no other catalogue. These are to be each once observed.

The Munich Zones are being completely re-reduced and brought up to 1880.0 with comparisons with Lalande, Bessel, Santini, Ruemker, Schellerup, Copeland, and Argelander.

O'Gyalla.—Stars are spectroscopically observed in the Zone 0° to — 15°. These observations include stars to 7 magnitude, and each star is observed twice. Special star spectra are more carefully investigated. Comet spectra have also been regularly observed. The color of all stars to 4 magnitude, inclusive, are observed with a Zoellner's colorimeter. The *Sun* was regularly observed (on 203 days). Many other investigations are also in progress, for an account of which reference must be made to the original report.

Padua.—The work of the observatory is intimately connected with that of the Italian Geodetic Commission.

The Observatory of Paris.—Admiral Mouchez's report on the state of this establishment and the work accomplished therein during the past year, commences with some details of his scheme for erecting a succursal observatory at a distance from Paris, where the disadvantages of location in the midst of a great city would be avoided. His proposal was to dispose of a part of the actual grounds of the observatory, a step which would be likely to realize a sum adequate to the erection of the new building, at the same time retaining the present one to form the headquarters of the bureau des calculs, the archives, and the museum, the two establishments to remain under the same direction and to constitute together the Observatory of Paris. This scheme, it is known, has not met with general acceptance at the hands of the scientific authorities.

M. Lœwy, in charge of the meridian service, has been occupied with the reobservation of stars in the catalogue of Lalande, while a large number of observations of the sun, moon, and planets has also been made, eighteen observers taking part in this work in the course of the year. The equatorials of 12 and 14 inches aperture and the equatorial *coudé* were employed on observations of comets and small planets. The Ecliptical Charts Nos. 12, 19, 48, and 67, have progressed, and attention has been paid to double-star measures. M. Mouchez reports that the construction and installation of the great telescope ($0^m74.$) has been retarded by the difficulty of establishing it in the grounds of the observatory at Paris. In the department of astronomical physics, MM. Thollon and Trépied had been occupied for six weeks on the Pic du Midi, where, with M. Naussinat, in present charge of the observatory, they

studied the advantages of the station, more especially for solar observations, concluding that great scientific interest would attach to work that might be accomplished during the four or five weeks of the fine season in a small observatory at that point. Funds for the purpose are not yet available.

M. Mouchez further reports upon the distribution of time in Paris, the additions to the museum during the year, which consist of instruments of the last century found in the Observatory of Toulouse, a portrait of Copernicus, etc.; the work of the bureau des Calculs, which remains in charge of M. Gaillot; the publications of the observatory during the year, including vol. XVII, of the *Annales*, in which are some important memoirs, theoretical and practical; and the personal work of the staff.

A plan of the grounds of the institution is appended, on which are distinguished those portions which M. Mouchez had proposed to alienate with the view to providing means for the erection of an observatory at a distance from Paris. (*Nature.*)

Plonsk (*private observatory*).—Solar spots are regularly observed, as well as the positions and spectra of comets and the relative situations of double stars.

Potsdam.—Dr. Vogel has had the privilege of using the large Vienna refractor during three months of 1883 for the investigation of the spectra of faint stars.

Jupiter and *Mars* have been regularly observed by Dr. Loehse.

Sixty-nine nebulæ have been observed for position with the heliometer.

The major planets (except *Uranus*) were photometrically observed each five times or more. Many variable stars have been observed. The *Sun* is observed constantly, and a great number of other researches are in hand.

Prague (*private observatory.*)—Professor Safarik has made 1,830 determinations of the magnitude of 97 variable stars on 161 nights, besides many other determinations of brightness as of the planets, comets, zodiacal light, etc.

Stockholm.—Dr. Gyldén's report relates chiefly to the progress made in his new method of determining the absolute elements of the eight major planets, and cannot be summarized here.

The meridian-circle is devoted to the observations of all stars north of $+45^\circ$ which are in the Radcliffe catalogue.

Zurich.—The *Sun* was observed on 302 days; 2,400 single positions of solar spots have been determined. *Jupiter* has been observed on 28 days, and observations of comets, etc., have been made.

Observatory of Algiers.—This observatory was reorganized in 1881. The director is M. Trepied, and the assistant M. Rambaud. The appropriation is 12,900 francs (about $2,600). The principal instruments

are a reflector of 20 inches aperture; a reflector of 13 inches aperture; a Thollon spectroscope, giving the dispersion of 31 flint prisms; a small meridian circle; spectroscopes; apparatus for solar photography. An account of this observatory is given in *Bulletin Astronomique* April, 1884.

Australian observatories.—The eighteenth annual report of the director of the observatory at Melbourne has been issued. The new transit-circle was expected in a short time, and would find the new circle-room ready to receive it, but the instrument which had been in use for twenty years continued to give excellent and trustworthy results; nevertheless, each year had forced upon Mr. Ellery the necessity of greater optical scope for the meridian work. The inevitable loss of reflective power in the great telescope increases a little year by year, but does not yet sensibly affect the work upon which it is employed. Indeed, Mr. Ellery says, "some photographs of faint objects obtained lately are clear evidence of the immense light-gathering power it still possesses, and of the trivial loss occasioned so far by the slight tarnish apparent." The instrument had not been kept quite so closely to its special work—the revision of the southern nebulæ—as before, owing to the number of nights occupied with the great comet, and in experimenting in celestial photography. Among the subjects of observation Mr. Ellery refers to the transit of *Venus*, the Port Darwin Expedition for determination of longitude of Australian observatories, and measures of differences of declination of the minor planets *Sappho* and *Victoria* for determination of the solar parallax, according to the scheme arranged by Mr. Gill. The great comet of 1882 was kept in view for 250 days, or until April 26, 1883. A large portion of the work connected with the telegraphic determination of the longitude of Australian observatories from Greenwich fell upon the Melbourne establishment, which is now assumed to be in longitude $9^h\ 39^m\ 53^s.37$ E., subject, perhaps, to some very small correction. As soon as the new transit-circle was properly adjusted, it was Mr. Ellery's intention to devote it to the revision of a rather large catalogue of stars, at the request of the *Astronomische Gesellschaft*, besides its more special work. The great telescope would be applied more exclusively to the continuation of the revision of Sir John Herschel's nebulæ, several of which, by the way, the Melbourne observers have not been able to find. (*Nature.*)

Observatory of Natal.—From a late issue of *Science* we learn of astronomical work now going on at Natal, under the direction of Mr. Edmund Neison, Government astronomer at that place. The following subjects are being pursued:

1. "The determination of the exact amount of parallactic inequality of the motion of the *Moon* by means of observations of the positions of a crater near the center of the lunar surface.

2. "The determination of the exact diameter of the *Moon* by observations of pairs of points near the limb.

3. "The effect of irradiation and its variations on the apparent semi-diameter of the *Moon*.

4. "The systematic variation of the apparent place produced by the irregularities on its limb.

5. "The real libration of the *Moon* by a method independent of the errors caused by abnormal variations in the apparent semi-diameter of the *Moon*.

Boswell Observatory.—A new observatory at Doane College, Crete, Nebr., has been recently erected, and is now being supplied with astronomical instruments. The equatorial telescope has an object-glass of 8 inches aperture, made by the Clarks. The mounting is furnished at Madison, Wis. Prof. G. D. Swezey, under whose directions the observatory is being equipped, has already secured a Buff and Burger transit instrument, a Howard mean-time clock, a Sewell break-circuit chronometer, a Seth Thomas clock, and a set of meteorological apparatus.

The building and instruments have cost about $7,000.

Chicago Observatory.—From the annual report of the director of the Dearborn Observatory at Chicago, Prof. G. W. Hough, it appears that the chief instruments have been kept in constant use. A gas engine is now employed to turn the dome covering the great telescope. The Repsold meridian circle is used only for observations connected with the time-service. The great telescope, of 18 inches aperture, has been exclusively employed in the observation of a few objects, (1) the Pons-Brooks comet, the changes in the structure of which were not remarkable; (2) difficult double stars, thirty-two new objects of this class having been discovered by Professor Hough; (3) the planet *Jupiter*, the principal objects of interest being the great red spot first noticed in 1878, and which has maintained its size, shape, and outline with very slight change, the great equatorial belt, which has been subject to gradual drift in latitude from year to year, and the equatorial white spots, which, with the envelope they are situate in, move with a velocity of 260 miles per hour, thus revolving about the planet in a month and a half; (4) the planet *Saturn*, with negative results so far as markings on or subdivisions of the rings were concerned; and (5) the satellites of *Uranus*, which were such difficult objects as not to have been frequently seen. Six drawings of *Jupiter's* disk were made, four of which are printed in the report. As heretofore, Mr. S. W. Burnham has continued his observations of double stars with the great telescope. (*The Nation.*) Professor Hough is experimenting with a printing chronograph.

Columbia College Observatory.—Mr. Lewis M. Rutherford, of New York City, has presented to the trustees of Columbia College the valuable astronomical instruments of his private observatory on Second avenue, as follows: A 13-inch equatorial telescope with mounting and clock-

work complete; a photographic lens with accessories for celestial photography; two micrometers for measuring double stars; four micrometers for measuring star plates; a transit instrument by Stackpole & Brother; a sidereal clock, and additional appliances for the observatory. Mr. Rutherford generously bears the expense of moving and of remounting the instruments.

Observatory of the University of Virginia.—Messrs. Warner and Swasey, of Cleveland, Ohio, have completed the great dome for the new McCormick Observatory at the University of Virginia. It is hemispherical in shape and is 45 feet in diameter, and a personal inspection has convinced the writer of its excellent qualities.

It can be revolved 360° in 80^s, by a pull of 15 pounds on a rope. The direct pressure required to move it is 45 pounds. The three shutters can be opened in 20^s, by a pull of about 10 pounds.

Willets Point.—A very interesting report is published by General H. L. Abbot, of the Corps of Engineers, U. S. Army, on the astronomical work which has been done during 1884 at the engineer post of Willets Point, New York Harbor. It is to this school of application that young officers of engineers are sent to learn the practical application of their studies at West Point. They are taught the practice of military surveying, mining, torpedo service, etc., and also the application of astronomy to military and boundary surveys. Each year a general order is issued, giving the results of the past year's work in practical astronomy. The order for 1884 may be summarized as follows:

Each officer makes a long series of determinations of local time with various instruments, and in various ways. With the portable transit, the time of transit is at first recorded by an assistant, at the word given by the observer; next, the observer records his own time by the *relay beat* of a chronometer every 1 second; next by the chronographic method, and lastly by the beat of the chronometer itself (every 0.5 second). Beginners use these methods in succession in the order named.

Personal equation is studied by means of Eastman's machine (see *Wash. Ast. Obs.*, 1875).

The time determinations are given for each day of observation, with the probable errors.

Time determinations by sextant observations are also given, and by means of the (known) correction of the standard chronometer the error of each observation and observer is determined.

We quote below the errors of the sextant clock corrections so determined. (Usually 10 altitudes of an east star and 10 of a west were employed). $3^s.0$; 3.8; 2.0; 1.2; 6.5; 1.8; 1.9; 0.9; 0.7; 0.1; 0.9; 1.0.

Observations for latitude were made by the sextant and by zenith telescopes. With the sextant the *errors* in seconds of arc were as follows ($1''$=101 feet): $6''.9$; $4''.3$; $2''.2$; $7''.4$; $1''.7$; 1.5; $10''.4$.

A table of the separate latitudes obtained by each observer, with

each instrument from each pair of stars (Safford's catalogue), is given in detail, and compared with the results of past years.

The mean of all the observations for latitude made in 1884, is as follows, all pairs and observations having equal weight:

Zenith telescope by Wurdemann (190 observations on 43 pairs) gives 40° 47′ 20″.47.

Zenith telescope, by Lingke (333 observations on 54 pairs) gives 40° 47′ 20″.92.

Grand mean for observations of 1884, giving observations and instruments equal weight, is 40° 47′ 20″.75.

The results of previous years are added for comparison (1″=101 feet:)

Transferred from old observatory	40° 47′ 21″.70 ± 0″.575
In 1880 (326 observations of 84 pairs)..	21″.59 ± 0″.082
1881 (591 observations of 104 pairs)	21″.47
1882 (235 observations of 60 pairs)..........	21″.37
1883 (497 observations of 118 pairs)........	21″.15
1884 (523 observations of 89 pairs)..........	20″.75

"The grand mean of 2,172 observations made at the new observatory during the past five years is 40° 47′ 21″.23; but it will be noticed that there has been a steady reduction in the yearly means during this entire period, and that the less exact determination at the old observatory indicates a change in the same direction."

Although the nature of the observations and the small absolute value of the quantity in question render it quite possible to attribute this solely to errors of observation, the fact is, nevertheless, an extremely interesting one in its relation to the question of the variability of terrestrial latitudes, and deserves further examination.

Longitude was determined by lunar culminations, and the errors of each separate result compared with the known (telegraphic) longitude were: 7ˢ.5; 36.0; 2.2; 15.1; 3.8; 10.4; 14.6; 5.5.

Longitudes by lunar distances were also determined with errors as below: 16ˢ.5; 12.9; 7.3; 6.7; 46.4; 39.7; 23.9; 11.7.

Auroral displays are regularly noted by the sentinels, and an interesting table of the results since 1870 is given.

What has been given as an abstract of one year's work in only one department of this school of application for young engineer officers is sufficient to show that we have at present no better school of practical astronomy in America.

Yale College Observatory.—The observatory in Yale College is now without a director, Professor Newton having resigned that office last May, being now the secretary to the board of managers, whose president is Dr. Porter, the president of the college. The points of most importance in the secretary's report for the year 1884 relate to the photographs of the late transit of Venus taken by Mr. Willson, and now in

the hands of the Government commissioner at Washington—photographs which Professor Harkness reports as "likely to yield valuable results"; to the partial reduction of observations made with the heliometer; and to the appointment in January, 1884, of Dr. Elkin as the astronomer in charge of this instrument for a period of three years. In addition to a thorough general investigation of the new heliometer, Dr. Elkin reports a series of observations of the diameter of the planet *Venus*, the determination of a large number of positions of the *Moon*, and good progress in his principal work, the triangulation of the group of the *Pleiades*. Mr. Sherman, assistant in the observatory, has been engaged in magnetic observations, and in determinations of the form, polarization, and position of the Pons-Brooks comet. The details of Dr. Waldo's report on the horologic and thermometric bureaus occupy more than half of the entire pamphlet. He notes a marked increase in the excellence of the watch-movements submitted to the observatory tests. An international system of watch trials has been agreed upon, by which the operations at Geneva, Kew, and New Haven will be strictly comparable. The work of the thermometric bureau has been much extended over previous years, and there has been a total of more than 6,000 thermometers examined. (*The Nation.*)

ASTRONOMICAL INSTRUMENTS.

In 1879 Privy Counsellor Otto von Struve, director of the observatory at Pulkova, near St. Petersburg, visited America and contracted with the Messrs. Clark for the construction of an object-glass 30 inches in diameter. It was completed last year and accepted by Dr. Struve, who came to this country to examine critically its performance. The mounting for this great glass has been made at the shops of the Repsolds, where many cardinal improvements in the mounting and mechanical accessories generally have been devised.* This telescope will be set up at Pulkova, and ready for work, at some time during the present year.

A section of Professor Newcomb's late report relates to the new equatorial *coudé* at the Paris Observatory, a refractor in which the rays of light are brought to the object-glass after reflection from two plane mirrors. The chief advantage of this construction is that the observer does not have to follow the eye-piece of his telescope, but always sits in a given position in a comfortable room. This form of instrument is not suitable when the highest optical power is sought; but it surpasses all others in convenience of use.

The French astronomers have lately devised a new method of supporting a revolving dome, wherein the base of the dome will be an annular caisson, floating in a similarly shaped trough filled with water so treated as to prevent its freezing. The dome to which this plan is to be applied is 65 feet in diameter.

* It is understood that the cost of this elegant and elaborate mounting was 36,250 dollars.

We learn from *Nature* that M. Charles Feil has, after some years' absence, returned to the active management of his celebrated manufactory of optical glass in Paris, the new firm being "Feil père et Mantois." M. Feil is grandson to M. Guinand, who, some sixty years since, by a mode of working almost identical with that adopted by the celebrated potter, Palissy, overcame the serious obstacles which occur in securing the perfect homogeneity of both crown and flint glass, and whose secrets have descended to his grandson. (*The Nation.*)

Lassell's 2-foot reflector at Greenwich.—The new dome for this telescope was completed by Messrs. T. Cooke & Sons at the end of last March, and is in every respect satisfactory. It is 30 feet in diameter, covered with papier-maché, on an iron frame-work, and turns with great ease. The shutter-opening extends from beyond the zenith to the horizon and is closed by a single curved shutter (3 feet 6 inches wide at the zenith and 6 feet wide at the horizon), which turns about a point in the dome-curb opposite to the shutter-opening, and runs on guiding-rails at the horizon and near the zenith, the curved shutter being continued by an open frame-work to complete the semicircle. This arrangement appears to leave nothing to be desired as regards ease of manipulation. The equatorial has required a number of small repairs and general cleaning, some parts of the mounting having been probably strained in process of removal, and the bearings in particular having suffered from wear and subsequent disuse, so that it has been necessary to raise the instrument and regrind these in several instances. The mirror has been cleaned, and appears to be in very good condition as regards polish. The definition on stars seems to be very good as far as it has been practicable to test it before the mounting of the telescope has been put into proper order. The delay in the completion of the dome has necessarily delayed the work on the instrument, which is now rapidly adancing to completion. (*Nature.*)

Dr. H. C. Vogel's opinion of the objective of the great Vienna refractor.—"In the spring months (1883), when there were several consecutive days of exquisitely clear weather, I got the impression that the objective was rather good, but that the images as regards sharpness were not to be compared with those of middle-sized instruments, and on leaving Vienna I had formed the opinion that the difficulty of producing so large objectives had not been quite surmounted, and that the advantage of large objectives principally consisted in the amount of light through which much detail would be revealed (though not with the sharpness of middle-sized instruments), which by a smaller amount of light would quite escape the eye of the observer.

"But by my observations in September this opinion was completely upset. I have acknowledged that the Vienna objective as regards the precision of the images leaves nothing to be desired, and that it was only from want of taking the state of the air into account that I had formed my former opinion. I have with advantage, on splendidly clear

evenings in September, used a power of 1,000 and even of 1,500, and perceived the fine details of planetary disks with admirable sharpness. The images of bright stars were of perfect regularity, and the central part of the diffraction disk was so remarkably small that it may be expected that the instrument would also be very suited for observing double stars."

The almucantar.—This is the name given by Mr. S. C. Chandler, of Harvard College Observatory, to an ingenious instrument devised by him. It consists first of a rectangular basin filled with mercury. In this mercury is floated a rectangle of metal, which carries a telescope movable in altitude. The mercury basin can be moved in a horizontal plane. The vertical transits of stars can be observed over horizontal threads in the telescope. Such results as have been published show the work of this instrument to be of surprising accuracy, and it certainly presents some important theoretical advantages.

Dr. A. Steinheil has given (Ast. Nach. 2606) in a brief form, a paper on the errors and adjustments of object glasses of two lenses, which should be studied by all observers who desire to understand the operation of their telescopes. An abstract of this has been printed in the *Sidereal Messenger.* Dr. Steinheil is prepared to furnish sets of objectives each of which has *one* of the errors named, but is perfect as respects the remaining ones. These should be of value in our physical laboratories.

Repsold's position-micrometer.—The price of a Repsold micrometer like that described in the *Encyclopædia Britanica*, vol. XVI—article micrometer—for a 15-inch telescope, is $1,250. This includes, of course, the fittings to the telescope which give the bright wire illumination.

Normal clock.—Dr. L. Waldo, *Science* states, has just completed the erection of a normal clock at the Yale College Observatory, to be used as a mean-time standard in the horological work of that institution. The movement and pendulum are parts of the gravity escapement clock built by Richard Bond (No. 367), and which had a phenomenal record under Mr. Hartnup, at Liverpool, and later under Prof. W. A. Rogers, of Cambridge. The case, from Dr. Waldo's designs, is built of cast iron, with planed back and front, to which are clamped the plate-glass doors. The entire case rests upon two brick piers, which rise to the height of the movement, and insure stability to the pendulum suspension. Thermometers, a barometer, and a cup of calcic chloride are placed within the case, which can be exhausted to any barometric pressure desired by an air-pump attached to its side. The escapement and arc of vibration can be observed and adjusted with the greatest accuracy. The clock is erected in the clock-room of the observatory, which was specially built to secure uniformity of temperature.

Division errors.—Prof. W. A. Rogers has devised a means of determining the division errors of a meridian circle mechanically without removing the circle from the axis. An abstract of his paper has appeared

in the *Sidereal Messenger*, and the method is to be applied to the Harvard College circle. It need not be said that there is hardly any problem in practical astronomy whose solution is more important than this, and Professor Rogers's final results will be waited for with impatience.

Declinograph.—Dr. Palisa has had a declinograph, on the plan of Dr. Knorre's at Berlin, fitted to the 12-inch Alvan Clark refractor at Vienna, and he is observing zones with even greater assiduity than usual. He reports himself as satisfied with the working of the instrument, which gives positions accurate to about $0^s.2$ and $2''$. In a zone 25^m by $20'$ 150 stars can be registered. The positions are to be reduced to 1875.0, and this is chosen as the equinox for all the new Vienna maps. Each map is to have a catalogue of its stars accompanying it, which is an excellent addition. Dr. Peters's catalogue of 60,000 zone stars would be of great usefulness, if it were available, as a supplement to his splendid series of celestial charts.

The price of the instrument is about $150.

Heliometer.—A new 7-inch heliometer is to be made for the Cape Observatory, for work in charge of Dr. Gill. It wi l cost £2,700, and is being constructed by Messrs. Repsold, of Hamburg.

ASTRONOMICAL BIBLIOGRAPHY, ETC.

Mr. Winlock is attempting a very extensive bibliographic task. It is the formation of a complete subject-index to every book in the library of the United States Naval Observatory. The entries are all to be entered in one alphabet. This is an immense work and will require much time. If special bibliographies of such subjects as Parallax, Photometry, etc., could be printed in advance they would be most useful, and the publication of a minute index to the V. J. S. *der Astr. Gesell.* is a want pressingly felt.

ASTRONOMICAL JOURNALS.

Besides the transactions of learned societies which have astronomy for one of their objects, we have at present the publications of two societies which are exclusively devoted to astronomy. These are the *Monthly Notices* of the Royal Astronomical Society, and the *Vierteljahrsschrift* of the German Astronomical Society. Besides these there are several journals exclusively devoted to astronomy, of which the *Astronomische Nachrichten* and the *Bulletin Astronomique* are by far the most important.

The *Monthly Notices* are chiefly short papers read at the regular meetings of the society, and abstracts of the larger ones, which are finally printed in full in the *Memoirs*. One number per year gives an interesting review of the work of the past twelve months, and a very full account of the proceedings of British observatories. The *Vierteljahrsschrift* devotes one of its four annual numbers to reports from the directors of observatories, chiefly in Germany and America. The other three

numbers are largely devoted to reviews of published work. Some of these reviews are of the highest order. To quote only recent ones, we may name Schoenfeld's review of Dreyer's paper on the constant of precession, and Auwers' review of Grant's Glasgow catalogue.

The German Astronomical Society is also concerned in the publication of the *Astronomische Nachrichten*, both directly and through its member, Professor Krueger, the editor.

The new impulse is plainly evident in the editing of this journal, which is of the best kind, as will be evident to all its readers and contributors. Nothing passes without scrutiny, and, in a way, the editor makes himself responsible for the accuracy of the articles printed.

On the theory of editing which is adopted, nothing could be more perfect.*

Copernicus, which had reached its third year of publication, has lately been discontinued, to the regret of all interested in the maintainance of high-class journals. But even before its last number it found a worthy successor in the *Bulletin Astronomique*, published by MM. Tisserand, Radau, Bigourdan, and Callandreau, in Paris. This journal has at once taken a very high rank. It contains observations, usually such as are made at French observatories, just as the *Astronomische Nachrichten* contains series of observations from all over the world. The *Bulletin* also publishes papers on special subjects, but its distinctive feature is monthly abstracts of other scientific journals, in which the articles cited are accompanied by very full and complete reviews. In this way the *Bulletin* does for France what the *Nachrichten* and the *Vierteljahrsschrift* do for Germany, and what the *Monthly Notices* does for England. The same thing was attempted by *Science*, in this country, but finally abandoned—unfortunately. England has, moreover, two special journals, the *Observatory* and the *Astronomical Register*, which cover slightly different fields; Germany has *Sirius*, and France has the new journal of Flammarion, *L'Astronomie.* In this country we have had the *Sidereal Messenger* of Mitchell, the *Astronomical Notices* of Bruennow, and the *Astronomical Journal* of Gould, all of which are now discontinued.

The *Sidereal Messenger*, published by Carleton College Observatory, is our only astronomical journal at this writing.

A new astronomical journal.†—An astronomical serial, under the auspices of the Observatory of Paris, will be a welcome addition to the literature of the science, and may well be expected to occupy a prominent place on the list of such periodicals.

Admiral Mouchez, in his introductory note, alludes to the great impetus which has been lately given in France to the progress of astronomy by the establishment or resuscitation of observatories, aided as well by national funds as by contributions from the municipal authorities

* Compare Bessel's *Recensionen*, p. 254.

† *Bulletin Astronomique*, publié sous les auspices de l'Observatoire de Paris, par M. F. Tisserand, etc. (Paris, Gauthier-Villars, 1884.)

of the places where they are located. In a few years these various observatories will be completely organized, the *personnel* consisting in part of astronomical students who have obtained their acquaintance with the practical branches of the science in the Observatory of Paris. The director therefore aims at providing a medium in the *Bulletin Astronomique* whereby the work of French astronomers may be speedily made known, and where at the same time an analysis of the contents of the principal foreign periodicals, etc., may be available to them.

The *Bulletin* will thus present two distinct sections: The first will be composed of observations of current interest, ephemerides of planets and comets, and memoirs or notices on various questions in theoretical and practical astronomy. The second will comprise as complete a *résumé* as possible of astronomical intelligence and an analysis of the principal periodicals and newly-published works. Further, in a supplementary section it is intended to introduce articles on subjects relating to the sciences allied to astronomy, as terrestrial physics, geodesy, and meteorology, not excluding points of interest in the history of the science. Contributions from foreign astronomers are invited. (*Nature.*)

The mathematical magazine conducted under the name of the *Analyst* for the past ten years, by Mr. J. E. Hendricks, will, we learn from *Science*, be continued under the editorial charge of Ormond Stone, professor of astronomy, and William M. Thornton, professor of engineering, with the title, *Annals of Mathematics, Pure and Applied.* The numbers will be issued at intervals of two months, beginning February 1, 1884. In scope the journal will embrace the development of new and important theories of mathematics, pure and applied; the solution of useful and interesting problems; the history and bibliography of various branches of mathematics; and critical examinations and reviews of important treatises and text-books on mathematical subjects. The office of publication will be at the University of Virginia.

MISCELLANEOUS.

The council of the Royal Astronomical Society have awarded the gold medal this year to Mr. A. A. Common, for his photographs of celestial bodies. President Stone, in placing the medal in Mr. Common's hands, remarked to the society that their council had been less influenced by originality in the methods adopted than by the great practical success which has attended the efforts of Mr. Common in this important field of astronomical research. He began with a 5½-inch refracting telescope ten years ago, and from time to time enlarged his facilities for celestial photography, until in 1879 he was in possession of a great reflector of 3 feet diameter, whose superior character is well known in astronomy from its behavior in observing the moons of Mars, and the fainter satellites of Saturn. Early in 1880 the first attempt

was made to photograph the nebula of Orion, resulting in failure; and it was not until 1883 that his magnificent photograph of the nebula was secured. This photograph excels all others, and, except in the very finest details, is far superior to any drawing. A few features can be seen with a large telescope which are not shown in the plate. Mr. Common was among the first to obtain a photograph of a comet. His photographs of Jupiter and Saturn are described as being beautiful, and he has lately applied himself with success in the direction of obtaining photographic star-maps. President Stone called attention to the fact that Mr. Common is an amateur astronomer, and that the records of their society are rich in the labors of amateur workers. The amateur who can provide himself with sufficient instrumental means for original research need fear no professional rivalry, and it is in work of this class that the most striking advantages in astronomy are to be expected. (*The Nation.*)

The address of Prof. C. A. Young, as retiring president of the Am. Assoc. A. S., at Philadelphia (1884, September 5), on the pending problems of astronomy is a careful review of the whole field of investigation, and is full of suggestions as to the directions in which research should be directed. It has been reprinted in many journals, and most widely read.

Professor Thibaut, of Benares, to whom we owe already many useful contributions to Sanskrit scholarship, has submitted to the Asiatic Society of Calcutta, a paper on the astronomer Varâha Mihira, which is soon to be published in the *Journal* of that society. The abstract of his paper contained in the *Proceedings of the Asiatic Society*, June, 1884, informs us that the dependence of Sanskrit astronomy on Greek astronomy is now proved beyond contradiction, and a new confirmation has thus been added to a theory lately propounded by several Sanskrit scholars, namely, that the so-called classical literature of India is in reality a mere *renaissance* belonging to the VI century A. D. (*Athenæum.*)

We are glad to announce the appearance of the fourth fascicule, completing the second volume of the valuable *Bibliographie Générale de l'Astronomie*, which is in course of publication by MM. Houzeau and Lancaster. It will be remembered that the scheme comprehends three great divisions, each to form a separate volume: (1) astronomical works; (2) astronomical memoirs and notices contained in serial publications and academic collections; (3) astronomical observations and observatories. Of these it has been considered convenient and useful to prepare and publish the second volume first, as it is on matters of more pressing and general interest than the others. The final part of this volume, which concludes with an index (occupying two hundred and thirty pages) of the papers and memoirs contained therein, under the names of the respective authors, is now before us, and we congratulate MM. Houzeau and Lancaster on the completion of the portion in ques-

tion of their laborious task. On its great utility to astronomers it is unnecessary to enlarge. (*Athenæum.*)

We have received from the Bureau des Longitudes their *Annuaire* for the present year, which seems thicker and more complete than any of its predecessors, well worth the money it costs (1*s.* 3*d.*) even to the English reader, on account of the very valuable tables which it contains touching astronomical and geographical subjects. We notice in the present edition a very complete table of the different comets, which alone would make it a necessity in any astronomical establishment. The semi-popular article published in the *Annuaire* for this year is entitled "Sur les Grands Fleaux de la Nature"; it is by M. Faye, and is well worth reading. (*Nature.*)

NECROLOGY OF ASTRONOMERS, 1884.

J. BIRMINGHAM: d. at Millbrook, Tuam, Ireland, Sept. 7.
EULOGIO JIMENEZ: d. at Madrid.
E. F. W. KLINKERFUES: b. Mar. 29, 1827; d. Jan. 28 at Göttingen.
C. MOESTA: d. at Dresden April 2, æt. 59.
H. SCHELLEN: d. at Cologne Sept. 5, æt. 66.
J. F. J. SCHMIDT: b. Oct. 25, 1825; d. at Athens Feb. 6.
C. W. STEVENS: d. at Cordoba Feb. 16.
I. TODHUNTER: b. 1820; d. at Cambridge, England, March 1.

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(*The prices are given in German marks.*)

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VULCANOLOGY AND SEISMOLOGY.

By Charles G. Rockwood, Jr., Ph. D.,

Professor of Mathematics in the College of New Jersey, Princeton, N. J.

The following summary for the years 1883 and 1884 cannot pretend to be complete. Neither the space nor the time at command would allow of even the mention of all that has happened or all that has been done and written in these departments in the two years. The writer has therefore preferred to make somewhat more full the account of those things which seemed most deserving of such record, even at the expense of passing unnoticed many things of interest and much good work that has been done, especially in foreign countries, where it is less accessible to an American writer. For all else the reader must refer to the authorities mentioned in the bibliography. The subjects will be treated in the following order:

Vulcanology:

Volcanic eruptions of 1883 and 1884.
Investigations of former volcanic activity.

Seismology:

Earthquake lists of 1882 and 1883.
Special earthquakes of 1883 and 1884.
Lists of former earthquakes.
Theories of earthquakes.

Seismometry:

Instruments and their records.

VULCANOLOGY.

In the last days of August, 1883, the Straits of Sunda were the scene of a catastrophe exceeding in magnitude and destructiveness anything that has heretofore come within the observation of civilized men. It has been the subject of numerous publications in the various languages (see bibliography,) from which the following condensed account is drawn:

The island of Krakatoa lies midway between Java and Sumatra, in the Strait of Sunda. It was about five miles long by three miles wide, rising into a triple mountain peak 2,700 feet high, and clothed with vegetation from base to summit. Near it are two small islands, Verlaten

on the west and Long on the east. It was considered by Junghuhn to be a continuation of the mountain system on the adjacent west coast of Java, and probably marks the position of an old fissure extending across the strait. It was entirely uninhabited, and only occasionally visited by fishermen from the neighboring coasts. The series of volcanic phenomena of which it was the scene began on May 20, 1883, with an eruption, the sound of which was heard at Batavia, 100 miles distant, and which had its seat in the most northern and lowest of the three peaks. Its first effect was the devastation of Long Island and the expulsion of large quantities of sand and pumice.

A visit to the island some time later showed the scene of this outbreak to have a maximum length of about 100 yards, and from it volumes of vapor and pumice dust were still rising, although as late as August 11th, trees were still growing on the main peak, which, indeed, was not active at any time in 1883.

The volcanic activity continued during June and July, extending in August to the second peak, and reaching a maximum on August 27; after that diminishing, but continuing for several days thereafter. The forenoon of the 27th was marked by a series of explosions, apparently due to the admission of the sea to the crater by the falling in of its northern walls. By the greatest of these explosions, occurring about 10 A. M., the whole northern part of the island, probably reduced to a shell by the previous eruptions, and including half of the main peak, was apparently blown into the air to an unknown height, the heavier *débris* falling partly upon the remaining portions of Krakatoa and Long and Verlaten, which were entirely covered by the deposit; partly into the sea to the east and northeast, where it formed two new islands, at first of considerable extent but which gradually disappeared by the erosion of the waves; while the finer dust reached the upper regions of the atmosphere and was carried away by the winds, to make its presence evident around the entire globe, and for many months afterward, in the peculiar ruddy glow of the sunset skies, which, first noticed in November, 1883, has not entirely ceased now, in the summer of 1885.

The noise of the explosion was heard over a circle of 30° radius, comprising more than one-fifteenth of the entire surface of the earth, and in some directions to even greater distances. At the island itself the greatest changes occurred. Its area had formerly been 33½ square kilometers, of which 23 square kilometers have entirely disappeared; and where there had been a considerable mountain, now the sea has a depth of over 300 meters. The remnant of the original area was increased to 15½ square kilometers by additions on the south and southwest sides, while the northern side was left a cliff 800 meters high. The extent of Long and Verlaten was also somewhat increased. Verbeek estimates the amount of ejected material to have exceeded 18 cubic kilometers.

The ocean wave caused by this convulsion devastated all the adjacent coasts, bringing death to thousands of the inhabitants, and extending

its influence to the coasts of America, where it was plainly marked on the tide-gauges in California and Alaska. On Java the whole west coast was swept by the wave, and the town and light-house of Anjer were completely destroyed, the wave there reaching a height of over 30 meters. In Lampong Bay, Sumatra, a Government vessel was carried three miles inland, and the bay was so filled with floating pumice that for weeks afterward vessels were unable to aproach the site of the ruined town of Telok Betong, at its head. Up to November 1, 32,635 victims of the catastrophe were counted.

The velocity of this ocean wave in its progress to distant stations was investigated by several persons. It was propagated most forcibly toward the Indian Ocean, and was distinctly marked at twelve of the seventeen Indian tidal stations, as well as at Port Louis, in Mauritius, and Port Elizabeth, in South Africa. For the two latter places Maj. A. W. Baird deduces the velocity of 467 statute miles per hour (*Nature*, XXIX, 358), both giving the same result, although the distances are 3,400 and 5,450 miles, respectively. This agrees with Airy's tabulated value for an ocean depth of 15,000 feet, which is supposed to be the average depth in this direction. The velocities in other directions were less, viz, to Galle, 397 miles; to Negapatam, 355 miles; and to Aden, 371 miles. Verbeek deduced a velocity of only 306 miles per hour to Port Elizabeth and 109 miles to Padang. (*Nature*, XXX, 10.)

Another and unexpected result of the Krakatoa explosion was the formation of an immense air wave, which was propagated several times about the earth in both directions, making its passage known by irregularities in the traces of the recording barometers in numerous meteorological observatories in all parts of the world. It was first recognized by General Richard Strachey (*Nature*, XXIX, 181), in a paper presented to the Royal Society in December, 1883, and later investigations abundantly confirmed his deductions. The wave made the circuit of the earth in about thirty-six hours, having thus a velocity approximating that of sound. The wave propagated from east to west had a mean period of $36^h\ 57^m$, that from west to east $35^h\ 17^m$, the difference being attributed to the motion of the atmosphere. The wave returned to the same station three or four times, gradually becoming imperceptible.

The far-reaching effects of the Krakatoa explosion have been traced in still another direction in the peculiar ruddy appearance of the sky at sunset and at sunrise. This first attracted general attention in America and Europe in the latter part of November, 1883. Many causes were suggested, and much discussion filled the scientific periodicals about them, but it has been pretty generally accepted that the appearances were due to the presence in the upper atmosphere of fine dust from Krakatoa. In support of this view are the facts that distinct evidence of volcanic dust, similar to that ejected from Krakatoa, has been found in rain and snow, and that the successive appearances of the red skies could be traced around the globe as the dust cloud gradually extended

itself to the westward, under the influence of the prevailing winds. The appearances continued in greater or less intensity through the year 1884.

The council of the Royal Society (London) appointed a committee for the purpose of collecting the various accounts of the volcanic eruption at Krakatoa, and attendant phenomena. Under date of February 12, 1884, the chairman, G. J. Symons, published a letter inviting authenticated communications. (*Nature*, XXIX, 355; *Science*, III, 244.)

Early in 1884 reports were received of the elevation of a new volcanic island near Bogosloff, one of the Aleutian Islands, but it was not until August that reliable information was at hand in regard to it. The volcanic activity apparently began early in 1883, and culminated in October, 1883, in a submarine eruption, resulting in the formation of a new volcanic peak some 450 feet high, which is not a separate island, but is connected with the north end of Bogosloff by a low sand beach. It was visited in May, 1884, by Lieut. G. M. Stoney, U. S. N., and was then still active (*Science*, IV, 432). The previous history of Bogosloff has been given by Dall (*Science*, III, 89) and by Davidson (*Science*, III, 282).

About the same time that the new peak appeared at Bogosloff, another Alaskan volcano, Mount Saint Augustin, on an island in Cook's Inlet, also became active. On the morning of October 6, 1883, an eruption occurred (*Science*, III, 187), which caused an earthquake wave 25 to 30 feet high at Port Graham, and was at first reported to have split the mountain in two from peak to base. It was also said that the northern half had sunk away to the level of the cliff. Later accounts, however (*Science*, III, 798), state that the reports were much exaggerated. The west side of the summit has fallen in, forming a new crater, but the mountain was not split and no waves of importance were observed. The volcano was, however, still active in November, 1884. (*Science*, IV, 474.)

On July 26, 1884, the light-house keeper at Cape Reykjanes, the southwest point of Iceland, saw what was supposed to be a new volcanic island in the sea, to the westward. But after having been the subject of various communications in the public press (*Nature*, XXXI, 37; *Science*, IV, 506), the reports of a new island were at last proved to be founded on a mistaken observation of a well-known island not usually visible from the mainland. No *new* island could be found. (*Nature*, XXXI, 149.)

Lieutenant Wohlgemuth, the leader of the Austrian polar expedition, found traces of still progressing volcanic activity in the island of Jan Mayen, and three times, while there, observed well-marked subterranean shocks. (*Nature*, XXIX, 246.)

In a monograph upon the volcano El Mayon, in the island of Luzon, read before the Seismological Society of Japan, Don E. Abella y Casariego has given a résumé of former eruptions, especially those of 1766, 1814, 1834, 1845, 1853, 1871, 1875, and 1881; and has discussed the hy-

drography, orography, and geology of the mountain. (*Trans. S. S. of Japan*, v, 19.)

Capt. C. E. Dutton, U. S. A., describes (*Am. Jour. Sci.*, XXV, 219) his observations during an extended examination of the volcanoes of the Hawaiian Islands. He visited the crater of Kilauea, watching the action of the lava in the lakes, and reaching the conclusion that it has no connection with Mauna Loa. At the latter the results of the great eruption of 1880–'81 were particularly examined. The largest lava stream from this eruption was 50 miles long and varied in width from half a mile to 2 miles. Comparing Mauna Kea with Mauna Loa, a difference in the character of the lavas is noted, and also their abundance of fragmental products on the former contrasted with the notable absence on the latter. The other volcanoes of Hawaii, as also those on Maui and Oahu, were visited, and abundant evidences of recent elevation were found, with marked traces also of subsidence in some portions.

Messrs. Hague and Iddings, of the United States Geological Survey, have given (*Am. Jour. Sci.*, XXVI, 222) some results of a reconnaissance of several of the extinct volcanic cones of Northern California, Oregon, and Washington Territory, made in 1870, but not hitherto published. The localities described are Lassen's Peak, Mount Rainier, Mount Hood, and Mount Shasta, and the article is mostly occupied with the lithological and chemical discussion of the rock specimens brought from these mountains. These four cones present many close resemblances in the character of their rocks. They are all andesite volcanoes, with extrusions of basalt breaking out upon their slopes and along the edges of the plain, extending in all directions for long distances.

SEISMOLOGY.

The eighteenth annual report of Dr. C. W. C. Fuchs describes the volcanic and seismic phenomena of the year 1882, mentioning an unimportant eruption of Vesuvius in January and February, the slight activity of Etna and Stromboli during the spring months, and a little-known eruption of Chiriqui, in Central America, in September.

The catalogue of earthquakes includes 217 items, classified in time as follows: *Winter*, 73: December, 19; January, 30; February, 24. *Spring*, 56: March, 34; April, 12; May, 10. *Summer*, 35: June, 5; July, 20; August, 10. *Autumn*, 53: September, 13; October, 28; November, 12.

Additions to his previous reports are given, numbering, for 1879, 37 items; for 1880, 56 items; for 1881, 114 items. (*Min. u. petr. Mitth.*, 1883.)

The only earthquake of importance in 1882, as reported by Dr. Fuchs, accompanied the eruption of Chiriqui, and extended throughout the Isthmus of Panama and the adjacent portions of Central America and the northern coast of South America. It occurred at 3^h 18^m on the

morning of September 7, 1882, and injured buildings in many places, causing the loss of a few lives.

The nineteenth report of Dr. Fuchs contains an account of the volcanic eruptions and earthquakes of 1883. (*Min. u. petr. Mitth.*, 1884.) Moderate eruptions of Etna during March and April are noted, and others during the year, from Vesuvius and Cotopaxi, and also in Iceland, Nicaragua, Colombia, and Alaska; but by far the most important outbreak was the great eruption of Krakatoa, already noticed here.

The record of earthquakes contains 263 items, distributed by seasons as follows: *Winter*, 56: December, 21; January, 21; February, 14. *Spring*, 66: March, 22; April, 20; May, 24. *Summer*, 68: June, 20; July, 29; August, 19. *Autumn*, 73: September, 29; October, 30; November, 31. The only one of importance was that in Ischia on July 28, 1883.

In his twelfth "Notes on American Earthquakes" (*Am. Jour. Sci.*, xxv, 353) C. G. Rockwood, jr., gives the record fcr 1882. It includes 72 items, classified geographically as follows: Canada, 6; New England, 5; Atlantic States, 6; Mississippi Valley, 11; Pacific coast, 19; Mexico and Central America, 18; West Indies, 5; Peru, 1. They may be classified by seasons thus: *Winter*, 11: December, 5; January, 3; February, 3. *Spring*, 18: March, 8; April, 6; May, 4. *Summer*, 14: June, 2; July, 6; August, 6. *Autumn*, 29: September, 7; October, 16; November, 6.

The only earthquake which caused any damage was that of September 7, 1882, on the Isthmus of Panama. Others of local interest in the United States occurred on September 7, October 22, and November 7. Thirty-six items are added to the records for the years 1879–'81, all referring to the Central American region.

In his thirteenth "Notes" (*Am. Jour. Sci.*, xxvii, 358) the record for 1883 is given.

There are 76 shocks noted, distributed geographically as follows: Canada, 8; New England, 3; Atlantic States, 2; Mississippi Valley, 11; Pacific coast, 23; Mexico, 1; West Indies, 4; Central America, 14; Peru and Chili, 10. By seasons they may be classified thus: *Winter*, 16: December, 4; January, 7; February, 5. *Spring*, 20: March, 9; April, 3; May, 8. *Summer*, 18: June, 3; July, 7; August, 8. *Autumn*, 22: September, 8; October, 9; November, 5.

Nearly all were but of moderate importance. The only ones meriting individual mention were: January 11, in Southern Illinois and adjacent portions of Missouri, Kentucky, and Tennessee; March 8, on the Isthmus of Panama and in the States of Colombia, in which churches and other buildings were injured; May 19, in Ecuador, overthrowing houses in Latacunga; October 6, at Mount Saint Augustin, in Alaska.

In summarizing his lists for the twelve years 1872–'83, Professor Rockwood finds that of the 364 earthquakes which are recorded for the United States and Canada, 151 occurred on the Pacific slope, 66 in the

Mississippi Valley, and 147 on the Atlantic slope, giving an average frequency of about one every twelve days for the whole region, and once a month for the Atlantic slope. (*Science*, IV, 569.)

On July 28, 1883, portions of the island of Ischia were devastated by a severe earthquake, which has given rise to a considerable amount of literature. The following account is condensed from a variety of sources mentioned in the bibliography:

Ischia contains about 26 square miles, and in the center of the island rises Mount Epomeo, 792 meters high, an old volcano, which during historic times has shown its activity only by hot springs and earthquakes. The thermal springs, with the pleasant climate, have made Ischia a favorite summer resort, and during the season the town of Casamicciola is usually crowded with strangers. There had been some previous indications of unusual subterranean activity—some hot springs had shown abnormal variations of temperature, some slight earthquakes were felt, and the instruments in the seismological observatories at Naples and Rome were in increased motion; but nothing gave any warning of where the blow would strike. The violent shock came about 9^h 25^m p. m. on Saturday, July 28, and the greatest damage was done at Casamicciola and vicinity. This town, built on two small hills on the north slope of Epomeo, was entirely destroyed. A performance was in progress at the theater, and when the building collapsed at the shock many persons were buried in the ruins. Lacco Ameno, on the coast northwest of Casamicciola, was also mostly destroyed, and Forio was much damaged. The town of Ischia, on the east coast, was severely shaken, without suffering serious harm. But the villages of Fontana and Serrara, situated in the interior of the island, and indeed within the old crater, were great sufferers, as was also Barano. Two large landslips were caused on the north slope of Epomeo, but no true fissures were found anywhere and no apparent changes of level. The number of casualties in the island, as stated by the official commission of the Italian Government, was 2,313 killed and 762 wounded. In Casamicciola there were before the shock 672 dwellings and 4,300 inhabitants, of which 537 dwellings were destroyed entirely and 1,784 people were killed.

In investigating the origin of this earthquake, L. Baldacci (*Boll. del R. Com. Geol. d'Italia*, IV, 157) traces two lines of hot springs, one east and west, the other north-northwest to south-southeast, which he regards as indicating the position of old cleavage lines intersecting at Casamicciola, and to which he attributes this earthquake. H. J. Johnston-Lavis (*Nature*, XXVIII, 437) has drawn isoseismals about the focus, finding them to be elongated ellipses whose minor axes are nearly in the line of the north and south fissure just mentioned, and concludes that they indicate a plate-shaped focus, whose strike extends in a line from Fontana to near the beach at Lacco. C. G. Rockwood finds the cause in a rupture taking place along an old volcanic fissure directed

roughly north and south and extending radially in or under the northern slope of Epomeo. (*Am. Jour. Sci.*, XXVI, 475.) Palmieri attributes it to the collapse of subterranean cavities, probably caused by the abstraction of matter carried away in solution by the hot springs. Fuchs says (*Min. u. petr. Mitth.*, 1884, 185) it was neither volcanic nor a collapse of a cavity, but only a rearrangement of the materials of the hill taking place at a moderate depth.

On August 10, 1884, between seven and eight minutes after 2 P. M., a decided earthquake occurred in the Middle and Eastern States, a brief preliminary notice of which was given by the writer. (*Am. Jour. Sci.*, XXVIII, 242.) It extended along the coast from Baltimore, Md., to Portland, Me., and westward to the Alleghanies. The origin was evidently not far from New York City. The shock was more violent than any which had been felt in that region for a considerable time.

Part second of the seventh volume (1884) of the Transactions of the Seismological Society of Japan is occupied by John Milne in the discussion of 387 earthquakes observed in North Japan from October, 1881, to October, 1883. It is accompanied by 123 maps of the areas affected by single earthquakes, and one general map shaded to represent the distribution of volcanic and seismic activity in Japan, and also 15 pages containing 66 figures of the tracings made by various recording instruments. As results of the discussion the author finds that 84 per cent. of the earthquakes originated under the ocean or on the eastern seaboard; that the winter intensity is nearly three and a half times as great as the summer intensity; that there is a general coincidence between the maximum of earthquakes and the minimum of temperature; and that there were 11.2 per cent. more earthquakes at low water than at high water. Sixteen of the earthquakes occurred simultaneously in separated areas, not being felt in the intervening districts. He also finds that the indications of exactly similar instruments may vary considerably at stations only a few hundred feet apart. Whence he concludes that the amplitude and period of the vibration constituting an earthquake are very largely dependent on the character of the soil and other local circumstances, and that therefore the direction of vibration in an ordinary earthquake has usually no immediate relation to its direction of propagation.

Thomas H. Streets, M. D., U. S. N., gives (*Am. Jour. Sci.*, XXV, 361) a list of earthquakes compiled from the weather statistics kept at the United States naval hospital at Yokohama, Japan. It includes all shocks, appreciable without instruments, that occurred in a period of four years beginning with 1878. They numbered 124, and, classified by seasons, were: Winter, 41; spring, 35; summer, 27; autumn, 21; showing a greater frequency in winter than in summer, as has been given by other lists. If March be substituted for December as a winter month, the contrast is still more striking, as we then find 51, or 41 per cent. of the whole number, occurring in those three months. February and

March appear to be the months of greatest earthquake activity. A period of earthquake calm is found in August and September, coincident with the period of greatest cyclonic activity.

Prof. J. P. O'Reilly, of Dublin, has prepared an earthquake map of the British Islands. (*Trans. Roy. Ir. Acad.*, XXVIII, 285.) It is based upon a catalogue of 53 earthquakes felt in historical times up to 1880, of which 8 occurred previous to the year 1700. These are rearranged and recatalogued with respect to localities and frequency, and the map is shaded accordingly. The most deeply shaded portions, indicating the greatest frequency, are found in Southern Scotland and in the neighborhood of Bristol Channel, and generally the map shows much more earthquake action in Great Britain than in Ireland; whence the author infers the existence of some barrier, such as great lines of faulting beneath the sea, which prevents the extension of seismic action to the adjacent island. He does not, however, allude to what is certainly the fact, that the probability of any slight earthquake passing unreported would be much greater in Ireland than in Scotland or England. The relationship of the areas marked by frequency of earthquakes to the great coast line directions, described in previous papers by this author, is discussed, and also the relation between the coal areas (which are marked on the map) and the earthquake areas; and the suggestion is made that if a similar investigation of European earthquakes on which he is engaged should confirm the indications of the map of England that coal areas are also earthquake areas, then the earthquake map might be an important aid in the search for concealed beds of coal.

In a memoir on the earthquakes of July, 1880, in the island of Luzon (*Trans. Seis. Soc. of Jap.*, V, 43), Don J. Centano y Garcia dissents from the conclusions of Father Faura, previously published, which placed the seismic center in an extinct volcano situated between Lepanto and Benguet, in the central mountain chain of Luzon. After an extended description of the effects produced by the earthquake, mostly based upon his own observation, he reaches the following conclusions: All the series of earthquakes from the 14th to the 25th of July, 1880, can be divided into three classes, corresponding to the 14th, 18th, and 20th days. The intensity curves for each of these periods, as drawn on the author's map, indicate that the seismic center was in the southern part of the island, near the lake called La Laguna, southeast of Manila, the curves of maximum intensity for the first two periods including the region just east of this lake, and for the third period its western shore.

In an article on Earthquake Disturbances of the Tides on the Coasts of India (*Nature*, XXIX, 358), we find some results reached by Maj. M. W. Rogers in a discussion of the earthquake waves which appeared in the Bay of Bengal on December 31, 1881. The probable position of the center of impulse was beneath the waters of the western part of the Bay of Bengal, and the velocities deduced for the sea wave were: To Port Blair, in the Andamans, 360 miles an hour; to Madras and Negapatam,

240 miles; to False Point, 180 miles; and to Dublat, at the mouth of the Hooghly, 120 miles. The average depth of the sea is known to diminish in every instance of diminished velocity, and in all these cases the crest of a positive wave preceded the trough or negative wave.

At the Minneapolis meeting of the American Association for the Advancement of Science (*Proc. A. A. A. S.*, 1883, XXXII, 253), Richard Owen discussed the grand lines of orographic development of the continental masses, and their relations to volcanic and seismic regions. He showed that a series of mountain chains, in several parallel ranges, extends nearly east and west from the land center in Switzerland to the equator at Quito and Sumatra, and that active volcanoes are often found in this stony girdle, while seismic activity is more often displayed within areas inclosed by the great orographic links of this chain.

G. K. Gilbert offers (*Am. Jour. Sci.*, XXVII, 49) a theory to account for the earthquakes of the Great Basin. The elevation of mountain chains being gradual, results in a slowly increasing strain upon the adjacent strata, which strain is from time to time relieved by the formation of faults at the foot of the range. This fault formation constitutes an earthquake shock; and the tension of the strata having been thus relieved, a longer or shorter period of quiescence will follow, until the tension again accumulates to the point of fracture. Applying these principles to the particular case, it is noted that fault scarps are found along the western base of the Wasatch Range and along the eastern base of the Sierra Nevada, one of the latter having been formed by the Owens Valley earthquake, which caused so much damage in 1872. But the fault scarp of the Wasatch is notably interrupted from Warm Springs to Emigration Cañon, near Salt Lake City, whence the inference is drawn that the strain of the rising mountains has not there been relieved in recent time, and consequently the inhabitants of that city may anticipate the occurrence of an earthquake shock to relieve this tension, which will be more severe the longer it is delayed.

In the first part of *Das Antlitz der Erde* (Leipzig, 1883) Edward Suess has discussed, in connection with other matters, both earthquakes and volcanoes. Having in the second chapter described several regions which are subject to earthquakes, as the Northeastern Alps, Southern Italy, Central America, and the west coast of South America, in the third chapter he discusses the general topic of dislocations and the strains which cause them, and in the fifth the different classes of earthquakes and their relation to more extensive movements of the crust. The fourth chapter is devoted to volcanoes, tracing the different stages in the life history of an eruptive mountain, as illustrated in the phenomena of the present day, from those which have broken forth within historical time and are still continuously active, through the succession of less and less active cones, to those which have not only been long extinct, but have been reduced to ruins by the processes of erosion, and finally to those masses of eruptive matter which never reached the sur-

face at all in a fluid condition, but have made their presence known only by the altered condition of the overlying strata.

On the theory that the motive power of volcanoes and earthquakes is due to the vapor of water, it becomes necessary to explain how water can be suddenly brought in contact with the heated portions of the interior of the earth in sufficient quantities to generate the explosive force called for by the phenomena. To meet this difficulty S. Meunier (*La Nature*, 1884. I, 379) assumes the crust to be thicker under the oceans than under the land, and suggests that at the edges of the thicker parts, that is, at the coast lines, masses may, by their own weight or by external strains, be cracked off from the solid crust, and may thus suddenly open a rapid communication between the included water of the upper strata and the zone of dissociation by heat below.

Under the name of Earth Pulsations, Prof. John Milne, of Tokio (*Nature*, XXVIII, 367), treats of movements of the soil which escape our notice on account of the *slowness* of their period. Showing that increase of atmospheric pressure or the rise of the tide would so change the load resting on the surface as to make such motions probable, he cites the increased activity of all microseismic apparatus, and the increased flow of gas from the pores of a coal seam attendant on the fall of the barometric column, as indications pointing in the direction of increased internal activity. Observation both in Italy and in Japan also shows that the position of rest of a suspended pendulum is not invariable, the variation from normal position being too great and too uniform to be attributed to accidental causes. Other illustrations are drawn from motions of the waters in English lakes at the time of the great Lisbon earthquake, and from the motions not infrequently reported of the delicate levels of astronomical observatories, which have not been accompanied by sensible movements of the ground. The same writer also discusses (*Nature*, XXIX, 290) the effect of earthquakes on buildings, and the kind of buildings best adapted to escape injury therefrom. Two plans are suggested: either to make the buildings strong and bind them together with iron rods, so as to resist the strains which occur, or to employ frame buildings comparable in structure to a wicker basket, which may yield without being overthrown. The use of heavy brick chimneys joined to wooden houses is especially condemned as dangerous.

The authorities of the University of Tokio have instructed one of their officers to devote himself wholly to the study of seismic phenomena. The person thus appointed is Mr. Sekiya, the Japanese secretary of the Seismological Society of Japan.

In November, 1884, a conference to formulate plans for the systematic observation and discussion of earthquakes in the United States was held in the rooms of the Geological Survey at Washington. There were present Messrs. J. W. Powell, C. E. Dutton, and G. K. Gilbert, of the Survey; C. Abbe and C. F. Marvin, of the Signal Service; H. M. Paul, of

the Naval Observatory; C. G. Rockwood, jr., of Princeton; and W. M. Davis, of Harvard College. Plans were arranged looking to the procuring of more accurate non-instrumental observations, and to the ultimate establishment of such instrumental observations as might be found practicable. To this end subcommittees of those present were appointed to consider the selection of instruments and the location of stations, &c., which committees are expected to report at a subsequent meeting of the conference.

At the Montreal meeting of the British Association, in August, 1884, a grant of £75 was made for the investigation of earthquake phenomena in Japan, and £25 for volcanic phenomena at Vesuvius. (*Science*, IV, 263.)

SEISMOMETRY.

An underground observatory has been established by Professor Milne at Takashima, near Nagasaki, in a coal mine whose workings extend beneath the island and the sea and have a total length of about 70 miles. It is proposed to carry on observations of the motions of the soil by means of microphones placed in the solid rock, by instruments to measure the "earth tremors," and by delicate levels, together with barometric and thermometric observations and observations of the escape of fire-damp, with the hope of determining whether any of these phenomena are connected with one another.

In seismometry proper the most important work is a memoir on Earthquake Measurement by J. A. Ewing, published as No. 9 of the Memoirs of the Science Department of the University of Tokio. It consists of seven chapters, with twenty-four plates, of which fourteen relate to the instruments and ten are copies of the records made by them.

The first chapter is devoted to a concise statement of the theory of earthquake motion; the difference between the normal and transverse vibrations, both being usually present; the greater velocity of the former, by which the two kinds of vibrations arising from the same shock become separated at a distance from their source; the effect of reflection and refraction at the bounding surfaces of the media traversed; the want of agreement between the direction of the wave within the ground and the motion impressed upon a particle at the surface; that is, in general, to the peculiarities of the phenomena to be observed.

In the second chapter, after theoretically determining the kinetic and static conditions to be fulfilled by the steady point of a seismometer, the author applies them to the horizontal pendulum, describing in detail the seismometer based upon it, and the improvements introduced by himself and others. The instrument consists essentially of a heavy mass pivoted through its center of inertia to one side of a light frame, which itself is so supported as to admit of motion with little friction about a vertical axis parallel to the line of support of the bob. The magnified record is made by a pointer attached to the frame and tracing

upon a moving smoked-glass plate. The proportions of the frame and pointer are such that the line of attachment of the bob is the center of percussion with respect to the vertical axis of support of the frame. Most of the important graphic records obtained in Japan have been made with some modification of this instrument. In its improved form the frame is made triangular and the bob is a truncated cone of cast-iron. Gray's conical pendulum, in which the upper pivot is replaced by an elastic wire, is also described, and a modification is suggested by which the lower pivot also may be dispensed with in a similar way.

The third chapter describes and discusses several previously used seismographs dependent on rolling spheres or cylinders, and various forms of pendulums making their records either directly or through the intervention of multiplying levers, and especially the author's "duplex" pendulum, which combines an ordinary with an inverted pendulum, so as to make the equilibrium of the system neutral.

The fourth chapter is devoted to instruments for recording vertical movement, which have already been described elsewhere.

The fifth chapter gives the results of instrumental observations in the case of nine earthquakes, selected from a much larger number recorded in Japan between 1880 and 1883, accompanied by fac-similes of the tracings made by various instruments, and a discussion of them.

The sixth chapter describes a number of miscellaneous instruments and methods of observation, none of which are new; while the seventh contains a brief statement of the author's results from a comparison of the records obtained with different instruments. He concludes that the only seismometers of value are those "which aim at giving a steady point or line during the disturbance."

In a paper read before the Seismological Society of Japan (*Trans. of S. S. of Japan*, VI, 22), C. D. West suggests a new type of seismograph, which is also described in an appendix to Ewing's memoir. It consists of a heavy weight supported by a system of links similar to those used in the Richards indicator to secure rectilinear motion. A weight so supported would be free to move in a horizontal line through a considerable amplitude without losing its astatic properties.

In the Journal of the German Geological Society (vol. XXXVI, 29), G. R. Lepsius describes a modification of Cacciatore's seismometer, in which the fluted dish is replaced by a watch-glass containing mercury, supported on the elevated central part of a porcelain dish whose outer part forms a ring of sixteen deep hollows, into some one of which the spilled mercury must fall. The whole apparatus has a diameter of 191^{mm} and a height of 60^{mm}.

Several forms of recording apparatus for earthquakes were suggested by Johnston-Lavis. (*Nature*, XXX, 609.) For the steady point in the registers of the horizontal component a pendulum was usually employed, and the direction and amount of its motion relative to the rest of the apparatus were recorded (*a*) by the pendulum pulling upon a cord

whose other end was attached to a stylus marking upon a moving drum; or (*b*) by making electrical contact in some one of a number of circuits arranged radially about the normal position of the pendulum, and thereby causing some one of a series of styles to record on a moving drum; or, for strong shocks, (*c*) by the pendulum turning the whole recording apparatus into the azimuth of its motion. Another device employed as a steady point a disk of lead between parallel glass plates and resting on spheres of glass or ivory.

For measuring the vertical component he proposed to use the changes in the rate of a falling body during the phases of the earth wave, these changes being recorded by appropriate apparatus on a moving drum. These suggestions were later commented on by J. A. Ewing (*Nature*, XXXI, 4), who justly criticised the want of novelty of some of them and the mechanical difficulties involved in others.

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(93) MARIE-DAVY.—Sur les oscillations barométriques du 27 août 1883, observées à Montsouris. [Compt. Rend. (1884), XCVIII, 246–248.]
(94) G. MERCALLI.—Sull' eruzione Etnea del 22 marzo 1883. [Atti Soc. Ital. di Scienze Naturali (Milan), XXVI, 111.]
(95) E. METZGER.—Gleanings from the reports concerning the eruption of Krakatoa. [Nature (1883), XXIX, 240–244.]
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(109) RICHARD OWEN.—The earth's orographic framework, its seismology and geology. [Proc. Am. Ass. Adv. Sci. (1883), XXXII, 253-256.]
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(113) H. M. PAUL.—Atmospheric waves from Krakatoa. [Science (1884), III, 504, 531–532.]
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(131) C. G. Rockwood, Jr.—Earthquakes in the United States and Canada. [Science (1884), iv, 569.]

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(133) A. Sauer.—Zur Zusammensetzung des Krakatoa-Asche vom 27. August 1883. [Chem. Centralblatt (1884), No. 12.]

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(137) Richard Strachey.—The Krakatoa air wave. [Nature (1883), xxix, 181–182.]

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(146) W. Topley.—The earthquake (England, April 22, 1884). (1 map.) [Nature (1884), xxx, 60–62. Abstract: Science (1884), iii, 740–742.]

(147) M. DE TRIBOLET.—Ischia et Java en 1883. [Conférence académique Neuchâtel, 1884.]

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(149) W. UPTON.—The red skies. [Science (1884), III, 37–40.]

(150) M. C. VAN DOORN.—The eruption of Krakatoa. (Trans. E. Metzger.) (4 figs. and map.) [Nature (1884), XXIX, 268–269. Abstract: Science (1884), III, 211.]

(151) C. VELAIN.—Le tremblement de terre d'Ischia du 28 juillet 1883. (2 maps, 2 pl.) [La Nature (1883), II, 182–187.]

(152) R. D. M. VERBEEK.—The Krakatoa eruption. (Translation.) [Nature (1884), XXX, 10–15.]

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(154) F. C. P. VEREKER.—Extracts from a report on the volcanic eruption in Sunda Strait. [Roy. Soc. Proc. (1883), XXXVI, 198.]

(155) H. VILA.—Nouvelle île volcanique dans Alaska. (1 map.) [La Nature (1884), I, 387–388.]

(156) E. VIMONT.—La grande éruption volcanique du détroit de la Sonde. [La Nature (1884), I, 70–76.]

(157) F. WÄHNER.—Das Erdbeben von Agram am 9. Nov. 1880. (2 maps, 2 pl., 17 figs.) [Sitzber. d. k. Akad. d. Wiss. Wien (1883), LXXXVIII, —.]

(158) J. T. WALKER.—On the earthquake of the 31st December, 1881. [Proc. Asiat. Soc. of Bengal (1883), 60.]

(159) J. T. WALKER.—Earthquake disturbances of the tides on the coasts of India. [Nature (1884), XXIX, 358–360.]

(160) W. J. WATSON.—The Java disaster. [Nature (1883), XXIX, 140–141.]

(161) C. D. WEST.—Suggestions for a new type of seismograph. (1 pl.) [Trans. Seis. Soc. of Jap. (1883), VI, 22–24.]

(162) E. WHYMPER.—Colored skies after an eruption of Cotopaxi. [Nature (1883), XXIX, 199–200. Science (1884), III, 99–100.]

(163) A. WITZ.—Coïncidences entre les phénomènes observés en 1831 et en 1883. [Compt. Rend. (1884), XCVIII, 542.]

(164) C. WOLF.—Sur les ondulations atmosphériques attribuées à l'éruption du Krakatoa et sur la tempête du samedi 26 janvier 1884. [Compt. Rend. (1884), XCVIII, 177–179.]

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(165) The new Bogosloff volcano. [Science (1884), IV, 138–139, 432–434 (map).]

(166) Catalogue of earthquakes felt in Tokio between Jan. 1, 1882, and March, 1883. [Trans. Seis. Soc. of Jap. (1883), VI, 32–35.]

(167) Catalogue of earthquakes felt in Tokio between July, 1883, and May, 1884. [Trans. Seis. Soc. of Jap. (1884), VII, pt. I, 43–45.]

(168) Tremblement de terre en Angleterre le 22 avril 1884. [La Nature (1884), I, 354–355.]

(169) An earthquake in England (April 22, 1884). [Nature (1884), XXIX, 602–603.]

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(171) The Ischian earthquake. [Nature (1883), XXVIII, 345–348, 374–375.]

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(179) The remarkable sunsets. [Nature, XXX, 20, 54, 194, 268, 359, 488–489, 511–512, 536–537, 559–560, 583, 607, 633–634.]
(180) Le grand tremblement de terre de Java, 27 août 1883. (Map and 2 pl.) [La Nature (1883), II, 260–263.]
(181) Curieux effets du grand tremblement de terre de Java. [La Nature (1883), II, 318.]
(182) La mission française au Krakatoa. [La Nature (1884), II, 186.]
(183) Curieux documents météorologiques. [La Nature (1884), II, 219–220.]
(184) The red sunsets. [Science (1884), III, 3–4, 172, 216, 302.]
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(186) The geological relatives of Krakatoa and its late eruption. (Reviews 21 and 24.) [Science (1884), III, 762–765.]
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GEOGRAPHY.

By Commander F. M. Green, U. S. N.

Among events of general geographical interest which have occurred during the past year, one of the most important is the meeting of the International Conference at Washington, in October, 1884, for the purpose of fixing upon a meridian to be employed as a common zero of longitude and standard of time-reckoning throughout the world.

This conference assembled by invitation of the President of the United States, in accordance with an act of Congress passed in 1882, delegates from the following countries taking part in it:

Austria-Hungary, Brazil, Chili, Colombia, Costa Rica, Denmark, France, Germany, Great Britain, Guatemala, Hawaii, Italy, Japan, Liberia, Mexico, Netherlands, Paraguay, Russia, Santo Domingo, Salvador, Spain, Sweden, Switzerland, Turkey, United States, and Venezuela.

After several consultations, the conference agreed unanimously that a single prime meridian is desirable, and, with only the delegates from France and Brazil dissenting, agreed to recommend to their respective Governments the adoption of the meridian passing through the center of the transit instrument at the Greenwich Observatory as the initial meridian of longitude, and also voted to recommend that from this meridian longitude shall be counted in two directions up to 180°; east longitude being plus, and west longitude minus.

Resolutions were also adopted in favor of adopting a universal day, to be a mean solar day, beginning for all the world at the moment of mean midnight of the initial meridian, and to be counted from zero to twenty-four hours.

An extensive chain of longitude measurements has been completed recently by the labors of the United States naval officers under command of Lieut. Commander C. H. Davis, U. S. N., in measuring from Panama down the west coast of South America to Valparaiso. The results of these measurements afford a remarkable proof of the accuracy of combined astronomical and geodetic observations at the present day, and are especially worthy of notice as being entirely homogeneous; that is, they are everywhere founded upon telegraphic comparisons of timepieces of which the errors on local time were determined, on the same

nights that the comparisons were made, by carefully observed transits of standard stars. This chain consists of the transatlantic longitude measurements of the United States Coast Survey from Greenwich to Washington; a Coast Survey measurement from Washington to Key West; a measurement from Key West to Panama, by way of Havana and Jamaica, by officers of the United States Navy, in 1874 and 1875; from Panama to Valparaiso, as mentioned above; from Valparaiso to Buenos Ayres, by way of Cordova, under direction of Dr. B. A. Gould; and from Buenos Ayres to Greenwich, by way of Rio de Janeiro, Madeira, and Lisbon, by officers of the United States Navy, in 1878 and 1879. In closing this immense chain of twenty links or connected measurements, the entire discrepancy amounted to eighteen one-hundredths of a second of time.

The longitude of the Observatory of Cordova was found to be:

Determined by way of Buenos Ayres	$4^h\ 16^m\ 48^s.06$
By way of Valparaiso	4 16 48 .24
	0 .18

NORTH AMERICA.

Among the scientific investigations and the geodetic, geographic, and hydrographic work which marked the progress of the United States Coast and Geodetic Survey during the past year, the following operations deserve special mention.

In order to complete the connection of the American and European initial gravity stations the observations needed were made at the Kew and Geneva Observatories.

A valuable series of comparative observations for gravity was completed at Washington with the Kater pendulums. These pendulums, of historic importance in connection with determinations of gravity in England and India, were swung at the station in the Smithsonian Institution, where they had been previously swung by an officer of the Royal Engineers.

The work of tracing out and marking the boundary line between Pennsylvania and West Virginia for the joint commission of these two States was completed; the resurveys of Long Island Sound and of Delaware Bay were advanced toward completion, also the topographical survey of the District of Columbia, for the Commissioners of the District; lines of level of precision were begun to connect the tidal levels of Chesapeake Bay and the Gulf of Mexico with the transcontinental line of geodesic leveling; progress was made in the primary triangulation near the thirty-ninth parallel for connecting the triangulation of the Atlantic coast with that of the Pacific; and trigonometrical surveys were continued in nine States which made requisite provision for their own topographical and geological surveys.

Developments of much importance to the interests of commerce and navigation were made during the year; dangerous shoals and ledges

having been discovered in some of the leading highways of commerce, among others in Monomoy Passage, Fisher's Island Sound, and the East River, New York. Immediate information of these dangers was given by the publication of "Notices to Mariners."

In pursuance of its plan for making a geographical map of the United States, topographic work has been pushed forward rapidly by the United States Geological Survey during the year in many different localities. In the State of Massachusetts work was commenced, in co-operation with the State authorities, under an arrangement by which the State agreed to pay one-half the expense, making therefor an appropriation of $40,000. Primary and secondary locations being furnished by the United States Coast Survey and the Borden survey, there remained in this State only the topography proper to be done, the estimated cost of which is $10 per square mile. Four parties were engaged upon this work through August, September, October, and November. An area of about 850 square miles was surveyed, the scale of the field-sheets being 1 : 30000, with a view to publication on a scale of 1 : 62500, or about 1 mile to an inch.

In the Southern Appalachian region there were six topographic parties in the field, two of which were fitted out for carrying on triangulation as well, while the triangulation for the remaining parties was supplied by a special triangulation party. The triangulation is in this region based upon the Appalachian and transcontinental belts of the Coast and Geodetic Survey. The topographic parties were dispersed over the area in question, from Mason and Dixon's line southwestward into Alabama. An area of about 18,000 square miles was surveyed in the States of Maryland, Virginia, West Virginia, Kentucky, Tennessee, North Carolina, Georgia, and Alabama. This work has been done with a view to publication on a scale of 1:125000.

In Southwestern Missouri and Southeastern Kansas an area of about 14,000 square miles was surveyed, comprising the lead and zinc regions of these States. The work was done with a view to publication on a scale of 1:125000.

A commencement was made in the State of Texas. A base line was measured near Austin, from which triangulation was extended over several of the neighboring counties. An area of about 4,000 square miles of topography was covered, with a view to publication on a scale of 1:125000.

In Northwestern Arizona, Southeastern Utah, and Southern Nevada several detached areas were surveyed, aggregating about 12,000 square miles. This work was done with a view to publication upon a scale of 1:250000. Besides this, a detailed map was made of the region including the San Francisco Mountains, upon a scale of 1:62500, or about 1 mile to an inch. During the season the triangulation in this section was extended so as to form a connection between the work done by the old organizations known as the Powell, Hayden, and Wheeler Surveys.

Work upon a detailed map on a scale of 1:62500, of the Yellowstone Park was carried forward during the season, so that at its close nearly all that part of the park lying west of the Yellowstone River has been mapped upon this scale, while the triangulation from the Bozeman base has been extended until a connection has been formed with that of the old Hayden survey coming up from the south.

The season in Northern California proved to be unusually favorable to topographic work, and the single party which was engaged upon general work, on a scale of 1:250000, made rapid progress. A second party was engaged during the season in making a detailed map of Mount Shasta and its immediate surroundings, the scale of the field-sheets being 1:20000.

Besides the work detailed above, a number of special mining maps, upon large scales, have been made during the past year.

The total area surveyed during the past season, upon all scales, is about 54,000 square miles, which has been done at an average cost of about $3 per square mile.

Bulletin No. 5 of the United States Geological Survey is a valuable dictionary of altitudes in the United States, compiled and arranged by Henry Gannett, esq., chief geographer of the Survey. The States and stations are alphabetically arranged, the number of altitudes given being about 18,000, referred to mean tide-level as the datum point.

Lieut. G. M. Stoney, U. S. N., commanding the Coast Survey schooner Ounalaska, and Lieutenant Cantwell, of the United States revenue steamer Corwin, have separately made explorations of the river Kowak or Kuak, a large river emptying into Hotham Inlet, Kotzebue Sound, on the western coast of Alaska, nearly under the Arctic Circle. First entered by officers of Captain Beechey's expedition in 1826, it was examined partially and its name was ascertained by officers of Her Majesty's ship Plover in 1849. It has been proposed to call this river Putnam River, after Lieutenant Putnam, U. S. N., lost from the United States steamer Rodgers, but geographers will probably adhere to the earlier name of Kowak or Kuak (the big river). The exploring parties traveled a distance of about 370 miles from the mouth of the river, finding it very crooked. The river banks are thickly wooded, and the country through which it runs is rugged and mountainous. Specimens of coal, gold, and copper were brought away. From the headwaters of one of the affluents of the Kowak a short portage could be made to the headwaters of an affluent of the Yukon, and from the sources of the Kowak it is but a short distance across the watershed to the waters of the Colville River, which empties into the Arctic Ocean. It is thought that commercially the most important result of the expeditions will be the indication of a route from the Arctic Ocean, available for the crews of ice-bound whalers, by way of the Colville and Kowak Rivers, to the settlements on the Yukon. Lieutenant Stoney, with a light-draught steamboat, will

continue the exploration of the Kowak River and its branches in the summer of 1885.

As stated in the *Summary* for 1883, a careful examination has been made of Bogosloff Island, in the Aleutian Archipelago, where an active volcanic disturbance took place in 1883. From the report of Lieut. G. M. Stoney, U. S. N., by whom the examination was made, it seems that, while no distinctly new island has appeared, Bogosloff Island (*Ionna Bogoslova*, St. John the Theologian) has been extended, the old volcano being supplemented by another, which is still active, and that where there was formerly deep water there is now land 300 feet high. On the 29th of May, 1884, Lieutenant Stoney, in the Coast Survey schooner Ounalaska, anchored close to the still smoking volcano and devoted three days to its examination. What had been reported as a new island was found to be a new formation, connected with the old island by a sand spit. The whole mass of volcanic rock was found to be constantly vibrating, and a thermometer inserted an inch and a half below the crust showed 250° F. (its limit) in a few seconds. A compass taken on shore indicated the presence of iron by marked local action. Though one of the party reached the summit of the crater, no estimate of its size or depth could be made, probably owing to the volumes of sulphurous smoke which poured out. By repeated measurements the altitude of its summit was found to be 357 feet.

The Canadian Government is naturally desirous to find a convenient outlet by way of Hudson's Bay for the great grain products of its northwestern territory, and with that end in view sent during the summer of 1884 an expedition in the steamer Neptune, under command of Lieut. A. R. Gordon, R. N., to establish six observation stations on the shores of Hudson's Bay and Straits, from the records of which an accurate judgment may be formed as to the length of the season during which the west shore of Hudson's Bay is accessible to steamers. Lieutenant Gordon, in reporting the establishment of the stations, argues that the stations should be continued for two or three years. They will be visited and supplies furnished as soon as navigation opens in 1885. The average of many years observations at Fort Churchill, a Hudson's Bay Company's post, and the only known harbor on the west coast of the bay, indicates that the coast cannot be approached before the middle of June, nor after the middle of November.

Considerable interest has been excited by an intimation from Sir J. H. Lefroy, in his address before the geographical section of the British Association at Montreal, that a lake "rivaling Lake Ontario, if not Lake Superior, in magnitude" had recently been discovered in the northeast territory of the Dominion of Canada.

In an admirable article in *Science* for January 2, 1885, Prof. J. D. Whitney shows that Lake Mistassini, the so-called new lake in question, has been known for more than two hundred years, although knowledge of its eastern side is yet indefinite both as to form and position, and

concludes, from all available evidence, that while it is possible that Lake Mistassini is larger than Lake Ontario, it is extremely improbable. The inference drawn by Sir J. H. Lefroy as to the size of the lake in question cannot be justified by any statement in the paper communicated to the section by the Rev. Abbé Laflamme regarding it. Explorations are now in progress to determine its actual extent and configuration. In a paper read before the annual meeting of the Quebec Geographical Society, Mr. Bignell, a land surveyor, gave an account of the country surrounding Lake Mistassini, and stated that he had explored the lake for 120 miles without reaching the main body of water. He expressed the opinion that the lake would be found to be an expansion of Rupert River, as the great American lakes are of the Saint Lawrence.

Mr. R. G. Haliburton (Journal of Royal Geographical Society, January, 1885) argues very plausibly and effectively in favor of placing "Vinland the Good," discovered by Eric the Red in A. D. 994, in Newfoundland instead of Rhôde Island. Mr. Haliburton points out that the test commonly relied upon to establish the identity of Vinland and Rhode Island, viz, the latitude consequent on the length of the shortest day there, has been completely disproved by the Icelandic-English dictionary of Vigfasson (Oxford, 1874), which shows that a correct translation would make the day much shorter than the shortest day experienced in the latitude of Rhode Island, and would consequently place the latitude of Vinland farther north.

SOUTH AMERICA.

One of the least known of the Brazilian rivers has been the Xingu, which was recently explored and mapped by three German travelers, Dr. Karl von den Steinen, Wilhelm von den Steinen, and Otto Klaus. These gentlemen left Cuyaba, in the province of Matto Grosso, in May, 1884, and proceeded by land to one of the sources of the Xingu which they named Batovy, for the president of Matto Grosso. They then, in July, embarked in canoes, and proceeding down the river, reached the junction of the Xingu and the Amazon in October, thence going to Para and Rio de Janeiro. Very many rapids were encountered, and numerous tribes of Indians were met who had never seen a white man and who use only implements of stone and of bone. The members of the expedition suffered severely from hunger during the first part of the trip, living entirely on beans for a month. Large quantities of India rubber trees were found, but the numerous rapids in the Xingu preclude the use of the river as a commercial route.

M. Emile Thouar, who is known from his journey up the Pilcomayo River in search of the unfortunate Crevaux expedition, has undertaken another journey in the same region. After ascending the Paraguay River he will devote some time to the examination of the Pilcomayo delta and to seeking an available trade route from Bolivia by way of the Paraguay River, and will then carry out the work with which he

has been charged by the Bolivian Government, viz, the study of the whole of Bolivia, in company with some engineers and naturalists, from scientific, industrial, and commercial points of view.

In the Journal of the Proceedings of the Royal Geographical Society for November, 1884, is given a sketch of the work of Dr. Paul Gussfeldt in the Chilian Andes in 1882 and 1883. His explorations were made in the region surrounding Aconcagua, the position and height of which were carefully determined as in latitude 32° 39′ south, longitude 69° 59′ west, and its highest peak 22,867 feet above sea level. His account of the glaciers of the Andes is very interesting, but cannot well be condensed. The detailed results of his labors are contained in a paper communicated to the Berlin Academy of Sciences.

The journey of Lieutenant Bove, of the Italian navy, to Terra del Fuego, performed at the instance of the Argentine Government, though frequently referred to in scientific periodicals, does not seem to have been productive of any specially new information regarding the geography of that region.

The first successful attempt to navigate the Rio Negro from its mouth, on the Atlantic shore of the Argentine Republic, to its source in Lake Nahuelhualpi, in the heart of the Andes, has been made by Capt. E. O'Connor, and is described by him in a report published in the *Boletin de la Sociedad Geografica de Madrid*. The journey was made in a steamer as far as the confluence of the Colluncurá, but rapids in the Upper Limay obstruct navigation so much that the journey was thence performed in an open boat. The extreme upper part of the Limay is free from rapids, but the country surrounding the upper river and lake appears to be entirely uninhabited. The information gathered will permit the affluents of the Rio Negro to be mapped with much greater accuracy than has been possible hitherto.

The enterprising journey of Mr. Everard im Thurn to explore and ascend Mount Roraima, on the boundary of British Guiana and Venezuela, has been crowned with success, but as yet no precise details have been published. Ascending the Potaro, an affluent of the Essequibo, as far as possible, a very toilsome march was made over rugged mountains to an Indian village on the southern side of Roraima. After resting here, the ascent was made on December 18, 1884. Mr. im Thurn states that the scenery on the top was of the most marvelous description, the plateau being covered with groups of rocks of most extraordinary shapes. The clouds, which are nearly always resting on the mountain, constantly precipitate their moisture, forming numerous cascades, the sources of rivers which, starting from this point, flow to swell the Orinoco, Essequibo, and Amazon. Mr. im Thurn determined the height of the summit from the temperature of the boiling point as 8,600 feet. He as well as his assistant suffered severely from malarial fever contracted during their journey, which was exceedingly laborious, lasting three months and a half.

The German expedition, under command of Dr. Schroeder, which spent the year from September, 1882, to September, 1883, at the island of South Georgia, is the first scientific expedition which has visited that island, and its report is therefore of great interest. The expedition was located at Moltke Harbor, in Royal Bay, and while their observations would seem to indicate that the neighborhood of Cape Horn was not as stormy during the year of their stay as has been generally supposed, one curious fact which navigators of those seas have frequently had occasion to notice was confirmed, viz, the violent storms occurred, without exception, when the barometer stood at "fair."

Explorations of the island were undertaken on several occasions, but the slate rocks were very difficult of ascent, and the enormous glaciers, rising in many places to a height of 6,000 or 7,000 feet, prevented any thorough examination. The climate was found to be decidedly colder than its latitude would indicate, its mean temperature for the year being only 35° F, the lowest thermometer reading being 26° and the highest 57° F.

EUROPE.

Measurements systematically made since 1750, and recently reported by the Swedish Academy of Sciences, demonstrate that the Swedish coast has been steadily rising, while the southern shore of the Baltic has been sinking, the general result being that the Swedish coast has risen nearly 56 inches during the last one hundred and thirty-four years.

The next ship-canal to be opened to commerce will be that across the Isthmus of Corinth. The work is being rapidly advanced, and another year only will probably be required for its completion. This canal will shorten the distance between the ports of the Adriatic and those of Western Turkey about 200 miles, and for vessels from the Atlantic about half as much.

A recent issue of the *Isvestia* of the Russian Geographical Society shows that geodetic and map-making work is being energetically carried on in the Russian Empire. Trigonometrical and hypsometrical surveys are being pushed in many regions, numerous latitude and longitude determinations have been made, and hydrographic work has been carried on in the Baltic, Black, and Caspian Seas and on the shores of the Pacific Ocean. A hypsometrical chart of European Russia, indicating the height of more than 18,000 points, has been published by the ministry of public works.

It has long been believed that Cape North was not the extreme northern point of Europe, and Captain Sorenson has now demonstrated that that distinction belongs to a promontory called Knivskjverodde, a few miles west of Cape North, and extending rather more than a thousand yards farther to the northward.

ASIA.

Colonel Prjevalsky, who spent the winter of 1883-'84 at Chobsen, a little to the eastward of Koko Nor, in Northeastern Tibet, resumed his explorations in the middle of March, crossing the Tsaidam or country west of the Koko Nor. This region he describes as a vast salt-marsh basin, the bed of a mighty lake at a comparatively recent geological epoch, and having a height of 9,200 feet above the sea. At the beginning of May the pass through the Burkhan Buddha Ridge was crossed at a height of 15,700 feet, and the table land of Northern Tibet was reached, a region quite unknown to geographers even now, and which the Chinese have repeatedly but vainly attempted to explore. The source of the Yellow or Hoang-ho River was found, about 70 miles south of the Burkhan Buddha Ridge, at a height of 13,600 feet above the sea. It is formed by two streamlets fed by springs in a wide, marshy valley. After flowing about 14 miles it enters two wide lakes in succession, and thence rushes furiously toward the boundaries of China proper. Colonel Prjevalsky describes the climate of Northern Tibet as inclement in the extreme. In the latter part of May wintery snow-storms occurred and the thermometer stood at $-9°$ F. at night. Through May, June, and July it rained every day, and sometimes for several consecutive days, frosts (23° F.) occurring every clear night. The amount of rainfall caused by the southwest monsoon in the Indian Ocean is so great that in summer Northern Tibet is almost one vast bog. Numerous herds of large animals were seen—yak, wild asses, antelopes, and mountain sheep, and bears were very frequently encountered, some thirty specimens being killed.

From the sources of the Yellow River a route was followed southward across the ridge separating the sources of the Yellow River from that of the Blue River or Yang-tse-Kiang. Journeying southward 60 or 70 miles, the banks of the Blue River were reached; but as fording was impossible, from the depth and rapidity of the current, the expedition returned northward along the lakes at the head of the Yellow River. These lakes, by right of discovery, Colonel Prjevalsky called Expedition and Russian Lakes. They are 13,500 feet above the sea; are each more than 80 miles in circumference, and are surrounded by mountains.

Fierce attacks were repeatedly made by the Tangutan robbers on the little force, fourteen in number, but were bravely beaten off without loss, and in July and August, 1884, the expedition returned to the plains of Tsaidam.

On their return journey a party of thirty gold-washers was found at the southern foot of the Burkhan Buddha. At these diggings the Tangutans went no deeper than 1 or 2 feet from the surface, and the method of washing was of a very primitive character, but whole handfuls of gold, in lumps as big as peas, were shown, and frequently much larger nuggets. Colonel Prjevalsky reports gold as very plentiful, and is of the opinion that with proper working vast treasures will be found

in this region. Returning to Gast, in Western Tsaidam, the expedition would go into winter quarters there, and would continue explorations of the surrounding country during the winter.

The Russian advance in Turkestan, and the surveys and explorations consequent thereon, will enable a great deal of detailed information to be added to the maps of the trans-Caspian region and Northern Afghanistan.

In the last volume published by the Caucasus Geographical Society are a large number of determinations of latitude and longitude made by M. Gladysheff in these regions, and also a great number of heights of points in Asia Minor measured by Russian officers.

M. Michael Venukoff has called the attention of the Russian Geographical Society to a new map of the island of Saghalin prepared by M. Nikitine, the topographer, and differing from all other maps of the island in several respects. By it the island is shown to be considerably larger than has been supposed, although any conclusions will be approximate rather than final, till more exact surveys are completed.

A journey, the results of which will furnish a mass of information regarding the interior of Indo-China and Northern Siam, has been performed by a party under the direction of Mr. Holt-Hallett. Starting from Moulmein in February, 1884, the expedition arrived in Bangkok toward the last of July, having spent more than five months in exploring the Shan country, surveying over 1,500 miles of route and determining the position of the Shan Ranges. This journey is another attempt on behalf of British merchants to find a satisfactory trade route from Southern China to the sea through Indo-China and Siam. Exploration of the southern frontier of China, which was proposed, had to be postponed, owing to the unsettled state of those regions. Mr. Holt-Hallett's report on his work in 1884 will shortly be published.

At a meeting of the Geographical Society of Paris on January 9, 1885, a paper by M. Francis Deloncle was read, giving an account of an exploration, February to June, 1884, made by the commission, of which he is the head, to investigate the question of a ship-canal across the Isthmus of Kraw, at the northern part of the Malay Peninsula. In *Nature* a synopsis of the results of the expedition is given. After ascending the peninsula to 7° 14′ north latitude, the explorers penetrated from the eastern coast, by wide and deep channels which lead far into the country, to a large inland sea called Talé Sah, which M. Deloncle states they were the first Europeans to visit. The lake is 45 miles long by 12 miles wide and about 20 feet deep, and separates the island of Tantalam from the peninsula proper by a number of *arroyos*, which extend from Singora in the south to Lacon in the north. Three visits in all were made to these regions during the year, and the states of Tsang, Taloung, Lacon, Singora, and Stouil were thoroughly explored.

In *Nature* for December 18, 1884, Mr. J. E. Tenison-Woods gives an excellent description of the physical geography of the Malayan state

of Perak, the commercial importance of which has rapidly increased within the last few years, owing to the great quantity of tin which has been produced there. Mr. Tenison-Woods considers the tin deposits practically inexhaustible. Now that order and good government have been secured by the presence and influence of a British resident, multitudes of Chinese have flocked to Perak, and, in mining industry, have entirely superseded the Malays.

The surveys and explorations by Russian and English surveyors of the territory in dispute between Russia and Afghanistan have led to detailed descriptions of the southern part of Turkestan and Northern Afghanistan from members of the boundary commission on both sides. In the January and March (1885) numbers of the Journal of the Royal Geographical Society, Major Holdich, R. E., commanding a British surveying party, gives a detailed account of the country passed over, and in the April number of the same periodical there is a translation of an article by M. Paul Lessar descriptive of the Kara-Kum or Turkoman Desert.

Various expeditions have been proposed for the exploration of the island of New Guinea, but the difficulties of hostile savages and a sickly climate are so great that very little has been added to our knowledge of that island during the past year. A Dutch gentleman, Mr. D. F. van Braam Morris, resident of Ternate, made two voyages to the north coast, and ascended the Amberno or Ambernoli River for 60 miles, finding it of much smaller dimensions than heretofore supposed. Mr. van Braam Morris discovered another large river and a good harbor, a little west of Humboldt Bay.

An attempt to penetrate by way of the Baxter River to the interior of the island, under the leadership of Captain Strahan (employed by the Melbourne *Age*), was frustrated by the hostility of the natives, who forced the members of the expedition to abandon their boat and retreat to the coast.

The proposed expedition of Mr. Wilfrid Powell, mentioned in the *Summary* of last year, has been abandoned.

AUSTRALIA.

Among the questions arising for discussion at the first annual meeting, at Melbourne, of the Victoria branch of the Geographical Society of Australia, are the necessity of defining the exact meaning of the geographical term "Australasia;" the compilation of a geography for Australian schools; the exploration of New Guinea, and the discovering and defining the exact boundaries of British New Guinea.

Mr. Charles Winnecke, between July and December, 1883, succeeded in exploring and mapping about 40,000 square miles of hitherto unknown country in South Australia near the western boundary line of Queensland. The country in question lies between 27° 30′ and 22° 40′ south latitude and between 137° and 139° east longitude. In this region,

hitherto a blank on the maps, Mr. Winnecke has discovered and named various lakes and mountains and one river, the Hay, an important feeder of the Marshall.

As another instance of the enterprise characterizing Australian newspapers in geographical matters, it may be mentioned that the *Town and Country Journal*, of Sydney, has employed Mr. Shaw, a naturalist and artist of Sydney, to make a canoe voyage down the Lachlan, Murrumbidgee and Murray rivers, with a view to enlarge the knowledge of the interior river systems of Australia.

Arnhem Land, the country northwest of the Gulf of Carpentaria, has been lately explored by Mr. D. Lindsay. All this region north of the Roper River is a blank on even the latest Government maps, but a large amount of material for filling up this blank has been obtained by Mr. Lindsay's surveys, made between July and December, 1883.

Dr. R. von Lendenfeld has been making an examination of the great Cordillera range of New South Wales for the geological survey department, and finds that Mount Kosciusko, commonly supposed to be the highest peak (7,171 feet), must give way to Mount Clarke, some distance farther south, 7,256 feet high. Indications of ancient glaciers were found at a height of 5,800 feet above sea-level, the upper tree limit being found at a height of 5,900 feet. On the lee side of the main range patches of snow are found all the year round above a level of 6,500 feet, constituting a proof, among many, of the lower temperature and greater amount of moisture south of the equator.

AFRICA.

In the continent of Africa the area of unknown territory is rapidly decreasing as explorations are made by travellers of different nationalities. The expedition commanded by Mr. Joseph Thomson, and fitted out by the Royal Geographical Society, to explore the area lying directly between the eastern coast of Africa and the Victoria Nyanza Lake, left England in December, 1882, and, after encountering many obstacles, started inland in July, 1883, from Tareta, at the foot of Mount Kilimanjaro, and for many months was unheard of. The wide tract of country lying between Mounts Kilimanjaro and Kenia and the Victoria Nyanza Lake had never been trodden by a European. Mr. Thomson visited and photographed both of these mountains. Mount Kenia he describes as a great volcanic cone nearly 30 miles in diameter at its base, rising from a thorn-clad plain 5,700 feet above the level of the sea. Up to a height of about 15,000 feet the angle of ascent is very low, but from that level the mountain springs into a sugar-loaf peak, the sides being so steep that in many places the snow cannot lie, the uncovered parts showing as black spots; hence the name Donyo Egaré (the gray mountain). From Mount Kenia Mr. Thomson pushed on, accompanying a caravan to the northwest, and after a six days' march reached Lake Baringo. This lake he journeyed round, fixing its shape, extent, and position, and thence pushed on to the

northeast shore of the Victoria Nyanza. Returning to the sea-coast the same general route was followed, but the energetic traveler was delayed by fever and accidents, by which he more than once nearly lost his life. He succeeded early in June, 1884, in reaching the sea-coast at Mombasa, having perfectly fulfilled the purpose for which the journey was undertaken, and having very largely increased the knowledge of the regions of equatorial Africa. Mr. Thomson showed the greatest courage, tact, and skill as an explorer in this remarkable journey, and the detailed account of his travels which has now been published is, throughout, of engrossing interest.

Mr. H. H. Johnston's exploration of Mount Kilimanjaro, undertaken under the auspices of the British Association and the Royal Society, during 1884, has confirmed and added to the information acquired by Mr. Thomson's journey.

French military geographers have completed, after four years' labor, a complete map of Tunisia from Algeria to Tripoli, in twenty-one sheets, on a scale of 1 : 100000. The sheets have been completed and published.

In the Journal of the Royal Geographical Society for November is an article by Sir R. W. Rawson giving an exact account of the partition of the entire coast of Africa between various European and native powers. This paper is accompanied by a map showing in a striking manner the claims of different nationalities.

ARCTIC REGIONS.

By far the most interesting and important event connected with Arctic exploration during the past year, has been the rescue of the survivors of the expedition commanded by Lieut. A. W. Greely, U. S. A., and the story of their achievements. Unsuccessful attempts having been made in 1882 and 1883 to communicate with the station established at Lady Franklin Bay in 1881 as one of the international meteorological stations, a squadron of three ships, the Thetis, Bear, and Alert, with officers and men of the United States Navy, commanded by Commander W. S. Schley, U. S. N., was fitted out by the United States Government in the spring of 1884 and sailed early in May for Smith Sound, to attempt the rescue of the survivors or learn the fate of the expedition. The Bear and the Thetis were Scotch whalers, purchased for the purpose; the Alert was given by the British Government for the expedition, and had already spent a winter in the Arctic, under command of Captain Nares, R. N. On June 22 the survivors of the expedition, consisting of Lieutenant Greely and six of his men, were found at Cape Sabine, in the last stages of starvation, one, Sergeant Ellison, dying after being taken on board ship. The rest were brought back to the United States, where they gradually recovered health and strength.

The expedition left St. John's, Newfoundland, on July 7, 1881, and was established on the shore of Discovery Harbor, where, in latitude 81° 44′, longitude 64° 45′, a station called Fort Conger was planted.

The first two winters were passed without loss or serious inconvenience, but the summer of 1883 passing away without news of a relief ship, the entire party left their camp on August 9, and were obliged to camp on the western side of the channel, near Cape Sabine. Here they remained till they were rescued, subsisting on what they could find of stores previously left in the neighborhood. Hunger and suffering reduced the original number of twenty-five to seven before they were rescued, and had succor been delayed but a few hours longer it is probable that not one would have survived.

The following sketch of the geographical work accomplished is largely taken from a communication to *Science* of February 27, 1885, by Lieutenant Greely, where it is accompanied by an excellent map of the regions visited, and from a paper by the same officer read at the meeting of the British Association at Montreal. In the spring of 1882 an attempt was made by a party, under command of Dr. Pavy, to proceed directly northward from Cape Joseph Henry, but they failed to reach the eighty-third parallel, owing to disruption of the polar pack north of Grinnell Land. In April, 1882, an expedition under Lieutenant Lockwood, undertook to explore the north coast of Greenland. Crossing Robeson Channel to Cape Sumner, a depot of provisions was established, and the explorers pushed on to the northeast as far as Cape Bryant, in 55°, west longitude, supported by three parties of men hauling provision sledges. From Cape Bryant, Lieutenant Lockwood and Sergeant Brainard, with an Eskimo and a dog-team, traveled across Sherard Osborn Fiord to Cape Britannia, trying the depth of water midway between those capes and finding no bottom at 800 feet. From Cape Britannia, which was the farthest land seen by the English expedition of 1875, they pushed on to the northeastward, till on May 15, 1882, Lockwood Island was reached, and its latitude carefully determined by circummeridian and subpolar observations as 83° 24′ north. To the northeastward land was seen in about 83° 35′ latitude and 38° west longitude. To the southeast only a mass of rounded, snow-covered mountains was seen. The entire coast was extremely rugged and precipitous, but only one glacier was observed. A remarkable feature, stretching along the coast from one head-land to another, was a tidal crack in the ice, apparently marking a separation between the ice of the bays and that of the ocean. Above the eighty-third parallel traces of the polar bear, the lemming, and the Arctic fox were seen, and a hare and a ptarmigan were killed. Returning, the same route was followed, Lieutenant Lockwood and Sergeant Brainard reaching Fort Conger without mishap.

In April, 1882, Lieutenant Greely, with three men, made a journey to the interior of Grinnell Land. Passing to the westward of Miller Island by a fiord, a river was reached flowing from a large glacial lake named Lake Hazen. Again in June this region was visited by Lieutenant Greely, who followed up the valley of Very River, flowing into the southwest end of Lake Hazen, till on July 4 he stood on the summit of Mount

Arthur, 4,500 feet high. From here could be seen an enormous ice cap on the mountains north of the Garfield and Conger Ranges, through the gorges of which numerous glaciers pushed southward, while to the northwestward the trend of the mountain range showed its connection with the Challenger Mountains of Lieutenant Aldrich. Lieutenant Greely found the southern limit of the ice cap covering Grinnell Land to closely coincide with the eighty-second parallel, while in July the country between the eighty-first and eighty-second parallels, extending from Kennedy and Robeson Channels to the Western Polar Ocean, was entirely free from snow except on the very backbone. Vegetation was found to be quite plentiful willows, saxifrage, grasses, and other plants growing in abundance. A more detailed account of this remarkably fertile region, such as Nordenskiold expected to find in Greenland, will shortly be given by Lieutenant Greely.

In 1883 Lieutenant Lockwood's attempt to reach the northern point of Greenland was unsuccessful, owing to open water, but on his return to Fort Conger he was sent with Sergeant Brainard and a dog-team to attempt the crossing to the western shore of Grinnell Land. They succeeded in reaching Greely Fiord, which penetrates Grinnell Land from the westward, and followed it some distance. From here the western shore of Grinnell Land could be indicated in about 87° west longitude, while to the southward very high land was seen, apparently separated from Grinnell Land, and was named Arthur Land. They found stretching from Archer to Greely fiord the northern edge of an immense ice cap, which had an average height on the perpendicular front of 150 feet. A journey from Cape Sabine by Sergeant Long developed the extension of Hayes Sound to the westward. As will be seen by a comparison of Lieutenant Greely's maps with those previously existing, a large addition has been made to our knowledge of the configuration of these northern shores by the labors of Lieutenant Greely and his gallant associates, and it is earnestly to be hoped that his health and strength will soon be sufficiently restored to permit him to give in detail the results of his labors, and the inferences which his experience and study enable him to draw from them.

In a paper read before the British Association at Montreal, Lieut. P. H. Ray gave an account of the region lying between the Yukon River and the Arctic Sea, previously unvisited. In 1883, with two natives, he traveled 160 miles due south from Point Barrow, as far as a low range of mountains running northeast and southwest and separating the northeast watershed from that of Kotzebue Sound. Farther than this his guides were afraid to go. Lieutenant Ray found the whole region a labyrinth of small lakes, lagoons, and streams, in summer impassable to every one but an Eskimo with his kayak, as at that season all that part not covered with water becomes a wet marsh, the traveler sinking through to the frozen ground underneath at each step. The

country is uninhabitable, destitute of timber, and without soil to support vegetation, the earth being strongly impregnated with salt. After two years of careful observation, Lieutenant Ray gives his opinion decidedly against the probable existence of an open polar sea, therein differing from Lieutenant Greely.

For more than a year an expedition, under command of Lieutenants Holm and Garde, of the Danish navy, has been engaged in exploring the east and southeast coasts of Greenland. Winter quarters for 1883–'84 were occupied at Nanortalik, 50 miles east of Cape Farewell. A journey lasting two and a half months was performed during the summer, but no account of the results of their explorations has yet been published. During the winter of 1884–'85 one-half the expedition were to winter in a suitable place on the east coast, the other half returning to Nanortalik. In consequence of frequent and violent changes of temperature, sledge journeys cannot be performed in this part of Greenland, the only means of conveyance being the boat. The programme is to explore the east coast by boats as far north as possible, and to return from Greenland in the autumn of 1885.

In June, 1884, Lieutenant Jensen, of the Danish navy, accompanied by Herr Lorenzen, geologist, and Herr Riis-Carstensen, artist, left Denmark for Holsteinborg, on the west coast of Greenland, to explore the coast southward from Holsteinborg to Sukkertoppen, a region never before examined by Europeans. The results of their work have not yet been published. From May to September, 1884, the Danish gunboat Fylla, Captain Normann, was engaged in examining the west coast of Greenland as far as 70° north latitude. This work included a careful exploration of the inland glaciers of Greenland, as well as dredging, sounding, and trawling along the coast and in Davis Strait, Baffin's Bay, and Disco Bay. Valuable collections were carried home to Denmark, including a block of ironstone weighing about 1,800 pounds.

The Russian expedition to the delta of the Lena River, commanded by Lieut. N. D. Jurgens, has returned, having lost no members and having had no serious case of illness. Scurvy made its appearance during the first winter of their stay, but was quickly suppressed. The lowest temperature experienced was —50° centigrade, with very frequent storms. The sun was hardly seen during the summer, and the highest temperature, 12° C., was only once reached. Many changes in the maps of this region will result from the surveys of this party. Sagastyr, where the observations were made, was supposed to be the northern point of the delta, but the most northerly land was found to be Dunas Island, in 74° north latitude. The tidal changes are very small and are largely influenced by the winds. Dr. Bunge, the naturalist of the party, has spent the winter of 1884–'85 in Irkutsk, and in the spring will visit and explore the basin of the Jana, in Northeastern Siberia. In 1886 he proposes to visit the New Siberia Islands.

The hopes of those who, like Baron Nordenskiold, looked for success for the trade route from Northern Siberia by way of the Kara Sea to Europe, seem doomed to disappointment. As has been before pointed out in these yearly summaries, no dependence can be placed on the navigability of the Novaya Zemlyan Straits in any year. During the last five or six years the steamer Louise has only twice succeeded in reaching the Yenesei and returning with cargo to Europe, having failed three times in the attempt. At Turukhansk, on the Yenesei, large quantities of wheat, rye, and oats have been collected to be transported to Europe, but there seems now but little prospect of these products ever reaching there. The tow-boats and lighters built for transporting freight to the mouth of the Yenesei are all to be sold, the difficulties of navigatting the Kara Sea making the success of the scheme hopeless. This conclusion agrees with the experience of M. Rakhmanin (cited by Dr. Schmidt, in a recent lecture on the Vega voyage), who had wintered twice at Spitzbergen and twenty-six times at Novaya Zemlya, and only found the way to the Yenesei open on five occasions.

In *Nature* for November 13, 1884, is a communication from Mr. W. G. S. Paterson, Her Britannic Majesty's consul for Iceland, who states that the light-house keeper at Cape Reykjanes, the southwest point of Iceland, had discovered a new volcanic island a few miles off that cape. This region has long been known as a center of volcanic activity, islands having been thrown up from time to time and afterwards subsiding. The island was sought for without success by the French cruisers Dupleix and Romanche, and by Captain Normann, of the Danish gunboat Fylla, on his return from Greenland. Captain Normann, after a careful search and many soundings, became convinced that the new island in question is no other than the outermost of the Fowlskerries, a well-known group of rocky islets.

An important element toward elucidating the currents of the polar seas has been furnished by the discovery by an Eskimo, on an ice floe in Julianhaab Bay, Greenland, of several relics of the ill-fated Jeannette expedition. These relics consist of various papers, articles of sailors' apparel, part of a tent, &c., and have been positively identified as belonging to the crew and officers of the Jeannette. Lieutenant Danenhower, U. S. N., one of the survivors of the expedition, states, in in a letter to the writer, that the articles were abandoned at the first camp, near where the Jeannette sank, on June 12, 1881, in latitude 77° 15′ north, longitude 156° east, and were exhibited on December 1, 1884, at a meeting of the Geographical Society of Copenhagen. These articles probably drifted north of Franz Josef Land and in close proximity to the pole. The direction and rate of the drift can only be approximately reckoned, but the distance being about 2,500 nautical miles, and the time occupied not far from 1,000 days, makes an average drift of 2½ miles a day, without allowing for deviations.

HYDROGRAPHY.

No new or striking developments have been shown by the hydrographic work of the different Governments engaged in making and correcting ocean and coast charts during 1884.

The results of the investigations carried on by the United States Coast Survey during past years in the depths of the sea off the North Atlantic coast and in the Gulf of Mexico and its approaches, are revealed in a striking manner by a model which shows the structural features of the two great basins of the Gulf of Mexico and the Bay of North America. This model, constructed under the direction of the Superintendent at the Coast Survey office, presents also representations in relief of the Bahamas, the West India islands, and the Bermudas, and of parts of the continent. The name "Bay of North America" was suggested by the Superintendent at the April meeting of the National Academy of Sciences, 1884, to designate that great embayment of the North Atlantic which lies west of the meridian of 60° longitude west from Greenwich.

The United States Fish Commission steamer Albatross, under command of Lieut. Commander Z. L. Tanner, U. S. N., has done a large amount of valuable hydrographic work, in addition to her regular work in connection with the fisheries. In January, 1884, while proceeding from Norfolk to St. Thomas, West Indies, many soundings were made, disproving the existence of the dangers to navigation called, respectively, the Ashton, Perseveranza, and Mourand Shoals. After leaving St. Thomas, numerous lines of soundings were made to define exactly the submarine ridge separating the Caribbean Sea and Atlantic Ocean, and to ascertain the general contour of the bottom, proving at the same time the non-existence of many *vigias* or shoals, the alleged existence of which has for many years disfigured the charts. This valuable work was continued until May, and data collected for wiping off many alleged shoals from the charts, among others the Loos and Leighton Rocks, off the south side of Santo Domingo; Sancho Pardo Shoal, off Cape San Antonio; the Ancona Breakers; and the La Vela Shoal. Aves islet, 100 miles west of Guadeloupe, was found to be the summit of a mountain extremely precipitous on its western slope and extending in a SSE. direction over 150 miles to the 1000 fathom line. On many of the alleged positions of shoals depths of over 2,000 fathoms were found, the greatest depth being 3,169 fathoms, about 60 miles southwest of the Grand Cayman Island, between the Misteriosa Bank and Thunder Knoll. During 1884 the Albatross made 701 deep-sea soundings, located with such accuracy as to give them a hydrographic value. In January, 1885, many additional soundings were made by the Albatross in the Gulf of Mexico.

In a paper communicated to *Science* for January 30, 1885, Commander Bartlett, U. S. N., gives an account of the various sounding

and dredging expeditions from whose labors the necessary material has been accumulated for making a complete relief model of the Caribbean Sea. During the cruise of the Challenger it was shown that in a submarine lake the temperature is constant to the greatest depth, and is the same as that of the ocean at the depth of the rim of the lake at the deepest point. The labors of Commander Sigsbee, U. S. N., from 1874 to 1878, while commanding the Coast Survey steamer Blake, showed that the temperature of the Gulf of Mexico below a depth of 800 fathoms is constant at 39½°, the normal temperature of the ocean at that depth in the region of the equatorial current. It was consequently inferred that the Caribbean Sea, from which the Gulf of Mexico receives its waters, is inclosed by a rim which was 800 fathoms below the surface at its deepest part. This inference has been completely borne out by the researches of Commander Bartlett and Lieutenant-Commanders Brownson and Tanner, of the United States Navy, and the results of their labors are admirably shown by a contour model of the Caribbean Sea exhibited at the New Orleans Exposition. This model is on a horizontal scale of 33 miles to an inch and a vertical scale of 6,000 feet to the inch.

Baron Nordenskiold has communicated to the Journal of the Royal Geographical Society a synopsis, by Herr Axel Hamberg, of the observations for temperature, specific gravity, and saltness of the expedition of 1883 to East Greenland and the adjacent waters, but no attempt is made to form any general deductions from the data presented.

The Danish gunboat Fylla, of 500 tons, Capt. C. Normann, was engaged during the summer of 1884 in surveying, sounding, and dredging on the west coast of Greenland and in Davis Strait. The greatest depth found was about 900 fathoms, while in the narrowest part of Davis Strait depths of only 400 fathoms were found. The ship was fitted with the very best appliances, a Sigsbee machine being used for sounding. In Disco Bay, where no soundings had been before made, depths of from 200 to 270 fathoms were found, while a ridge on which there are but 180 to 190 fathoms constitutes a sort of threshold between the bay and Davis Strait, preventing icebergs with a greater height above the water than 150 feet from passing from the great fiord of Jacobshavn to the ocean, the average proportion between the exposed and submerged surfaces being as 1 to 8.8. As was the case with the Nordenskiold expedition to East Greenland, it was found, in taking serial temperatures of sea-water, that the coldest water is not found nearest the bottom, but that the temperature increases with the depth in the polar current and underlying water layers.

METEOROLOGY.

By CLEVELAND ABBE.

PREFATORY NOTE.

The following pages take up the subject of Meteorology and closely allied matters where our last summary closed, and present a series of short abstracts and notes relative to the principal meteorological items that have been published up to the end of 1884 in the special meteorological journals, namely, the *Zeitschrift* of the Austrian Meteorological Association (*Z. O. G. M.*), Vols. XVIII, XIX; the *Zeitschrift* of the German Meteorological Association (*D. M. Z.*), Vol. I; the *American Journal of Meteorology* (*A. J. M.*); the English Journal *Nature*, Vols. XXVII, XXVIII, XXIX, and XXX.

The compiler has, even more frequently than in former years, taken the liberty of adding to these abstracts occasional remarks of his own, generally historical, which, to avoid confusion, are now inclosed in brackets, [ ], and he hopes that these will not be taken amiss by the reader and those to whom they may refer.

By numbering each of the items in a heavier type, and by an index referring directly to these articles, the reader will, it is hoped, utilize the information here brought together more easily than by relying solely upon the general arrangement of the twelve chapters.—C. A.

CONTENTS.

CHAPTER IX.—(a) General storms; (b) Local storms; (c) General weather relations.

CHAPTER X.—(a) Atmospheric electricity; lightning; (b) Terrestrial magnetism; (c) Ground currents; (d) Auroras.

CHAPTER XI.—(a) Refraction and mirage; (b) Scintillation; (c) Spectroscopy, photo-spectroscopy, phosphorescence, etc.; (d) Halos, rainbows; (e) Photometry, colorimetry, twilight, etc.

CHAPTER XII.—Miscellaneous relations. (a) Periodicity and sun-spots; (b) Hypsometry; (c) Biology and botany; (d) Glaciers and climates of geological epochs.

I.—(a) INSTITUTIONS AND PERIODICALS; (b) SPECIAL STATIONS; (c) INTERNATIONAL POLAR WORK; (d) INDIVIDUALS AND NECROLGY.

1. Dr. W. Köppen, in reference to the distribution of meteorological stations, says that the complaint still comes, on the one hand, of the immense mass of meteorological figures written and published annually without corresponding results, and, on the other hand, of the great want of proper data whenever any new question is proposed. This state of affairs results from the nature of meteorological work, and will probably continue permanently. [Every new question in physics is tested by means of new apparatus and experiments, but in meteorology, as in astronomy, we can do but little experimenting, and must derive our knowledge from the discussion of a large mass of observations taken under widely different circumstances. In both these latter studies the observations must be published to as great extent as possible, as no one can foresee how soon they will be wanted in reference to some new question, nor how long the world must wait to accumulate new observations whereby to answer that question in case those already made be not thus rendered available. The experiments and apparatus in chemistry and physics vastly outnumber the observations in meteorology, but do not need to be published in full, as they can be easily repeated at any time.] More homogeneity could perhaps be given to the work by the formation of an international institute for the direction of observations and investigations, but in the present system of individualized activity we find stations that have the following peculiarities: (1) Those with very comprehensive and complete observations, and corresponding publications; (2) stations in such isolated situations that they must be used to fill up great gaps in the weather chart of the world; (3) stations with long-continued uniformly-comparable records; (4) groups of stations, such that the differences in latitude and longitude are slight and the differences in topographical conditions are large. Each of these groups gives data proper to solve some special question, such as the geographical, the chronological, and topographical distribution of climatic peculiarities, the investigation of physical and mechanical details as to special storms or other phenomena. [Special stations for rainfall, thunder-storms, tornadoes, auroras, have also been started in great numbers for the solution of the respective subjects, and others for the study of glaciers, fog, frosts, hygiene, forestry, phænology, and various agricultural questions.] Köppen's idea seems to be that at present we need a greater

number of the special stations, or, in lieu thereof, a large number of stations with self-registering apparatus, so located as to represent for any country the greatest variety of typical altitudes, valleys, slopes, summits, forests, shores, plains, &c. Climatic data from such stations for ten years would answer any question bearing on any new locality, in addition to which are needed two or three temporary experimental fields on which ten or twenty stations can be arranged. [The general weather service of the Signal Office offering about two hundred stations, or about one station to every 10,000 square miles, if it could be extended over the whole world, would offer a fair basis for the general study of meteorology as a dynamic problem. It is only when we study the innumerable applications of this science to the wants of mankind that we are confronted with the practical impossibility of securing enough stations and observations to satisfy all requirements. The best solution of the difficulty seems to be the maintenance of first and second class stations for weather telegraphy and general storm study, and the maintenance of third-class and special stations to deal with the special questions that are suggested by the meteorological student, as well as by the various branches of human industry.] (*D. M. Z.*, I, p. 437.)

2. [The progress of meteorology in America promises to be greatly stimulated by the formation of state weather services, which will, it is hoped, give for the respective states a detailed study of local climate and its relations to agriculture and to human industry. These services will also be the medium through which predictions of local thunder storms, tornadoes, cold waves, &c., can be communicated to the people in detail. The first organization of this kind dates from early in the century, when New York, Pennsylvania, and possibly other states, showed some activity in this direction. After a long period of neglect, the subject was revived in 1875 by Professor Hinrichs, who started a state service for Iowa, which has ever since been carried on most successfully. The formation of additional services has been the direct result of a circular and other correspondence between General William B. Hazen and the governors of the respective states. Similar services now exist in some fifteen different states, some of which publish very excellent monthly reviews, while others contribute their observations directly to the Army Signal Office for use in its monthly weather review. It is evident that in this way the study of meteorology and the utilization of the work of the Signal Office will both be furthered, and that, on the other hand, the general service, namely, the prediction of general storms and weather features, will be more especially fostered by the Signal Service.]

3. An important step for American meteorology has been the starting of The American Meteorological Journal, a monthly review of meteorological matters, edited by Prof. M. W. Harrington, of the University of Michigan, at Ann Arbor. The desirability of some such journal has been for a long time felt, but the definite impulse to the

present undertaking seems to have been given by letters from various meteorologists suggesting to Professor Harrington the hope that he might undertake it. So far as the financial success of this journal is concerned there can evidently be no doubt, provided its columns successfully combine the scientific and the popular features that in Germany have been divided between the two journals published at Hamburg and Magdeburg, respectively.

Among the principal articles that have appeared in the journal during 1884 are the following:

Prof. T. C. Mendenhall, History of the Ohio State Meteorological Bureau, established April 17, 1882.

Prof. H. M. Paul, Barometric Waves of Very Short Period.

Prof. William M. Davis, Winds and Currents of the Equatorial Atlantic.

A. J. Phinney, The Oakville Tornadoes.

Prof. H. A. Hazen, Exposure of Thermometers. The Sling Psychrometer.

Lieut. J. P. Finley, Tornado Predictions.

Prof. William M. Davis, The Relation of Tornadoes to Cyclones.

H. H. Clayton, Meteorologic Cycle. (Showing a barometric and rainfall oscillation every twenty-five months.)

G. K. Gilbert, Tornado Predictions.

Prof. H. A. Hazen, Tornado Generation.

L. A. Sherman, Movements of Weather-Areas.

H. H. Clayton, The Thunder Squalls of July 5, 1884.

H. M. Paul, Thermometer-Exposure.

Prof. F. H. Loud, Diurnal Wind Variation at Colorado Springs.

4. [Beside the State weather services, the meteorological magazines, and the meteorological instruction in colleges, another powerful help in scientific progress is the organization of meteorological societies in the United States. An occasional paper on some meteorological subject is read before some geographical or scientific society, the most active in this respect being the Philosophical Society of Washington, in which there is material sufficient to form a special meteorological section. An effort was made at the Philadelphia meeting of the American Association for the Advancement of Science to secure the recognition of meteorology by organizing a section of terrestrial physics as distinguished from molecular physics, and this may possibly be accomplished on some future occasion. The honor of establishing the first special society for the study of our science belongs to Prof. W. Upton and Mr. E. B. Weston, both of Providence; Mr. W. M. Davis and Prof. W. H. Niles, of Cambridge; Mr. D. Fitzgerald, of Boston, and a few others (including the present writer), who held the first preliminary meeting of organization in June and the first annual regular meeting on the 21st of October, in Boston. This society will for the present make a special effort to secure more numerous rainfall, thunder-storm, and possibly other special ob-

servers, in New England; they have established standard gauges of three different patterns, and have published a monthly bulletin, with rainfall map and other data. It is hoped that by the co-operation of the states of New England this organization may become a New England weather service.]

5. In order to collect data for the information of Government on the proposition to run steamship lines from England to stations on the shores of Hudson's Bay, and thus afford British America a convenient outlet for its immense product of grain, Lieut. W. R. Gordon has, under the Canadian Meteorological Service, established seven stations on the shores of the bay, at which observations were begun in the autumn of 1884. These stations will contribute invaluable information for the study of North American storms and climate. A sketch of the location of each is given by W. P. Anderson in the Cambridge journal, (*Science* for March 13, 1885,) full details being given in the report of Lieut. W. R. Gordon. (See also *Nature*, xxx, p. 641.)

6. Dr. B. A. Gould has published additional volumes of the Annals of the Meteorological Office of the Argentine Republic, which contain original observations in full, and many interesting items relative to Buenos Ayres, Paraguay, and Patagonia. (*Z. O. G. M.*, XIX, p. 130.)

7. In connection with the proposed canal across the Isthmus of Panama regular meteorological observations are being made at several stations. The average temperature varies from 25° F. in winter to 85° F. in summer. Two large hospitals at Panama and Colon, respectively, and a health resort at Taboga afford opportunity for regular observations on climate and hygiene. (*Nature*, xxx, p. 580.)

8. The Academy of Sciences at St. Petersburg proposes a special committee to which shall be committed the general direction of the magnetic and meteorological works that have for some years been carried on by various Government officials, especially the physical observatory, the geographical society, the bureau of agriculture, and the imperial navy.

9. (See sect. 73′.)

10. H. F. Blanford, in his annual report on the administration of the meteorological department of the Government of India for 1883, states that work on the physics and temperature of the sun and on the absorption of the earth's atmosphere has steadily continued. Special reports have been made on the snowfall in India and the Himalayas, which have led to a theory of the dry winds and droughts, and he urges a special study in the future of the meteorology of this high mountain region. Data have been collected together for charts of distribution of temperature in Northern India, which will appear in the next or second part of Vol. II of the India Meteorological Memoirs. A very large and elaborate chart of the average annual rainfall in India has been published with the co-operation of the surveyor-general's office. He is also himself at work upon a number of interesting questions as to the

annual distribution of rainfall and the cause of the droughts. Much pains have been taken to increase the number of rainfall observers; and an elaborate discussion of special cyclones by his assistant, Mr. Elliot, shows that the origin, continuation, and movement of a storm depend only upon the atmospheric conditions in the region visited by the storm and not on anything outside of this region, so that the weather normal to the season prevails over surrounding countries, while storms move over the Bay of Bengal. The great collection of meteorological observations made in the Indian Ocean since 1856, as collected by the London Meteorological Office, has been purchased from that office, properly corrected by the India office, and is now under discussion by Mr. Elliot and Mr. Dallas. The chapter relating to barometric observations is substantially completed. The new system of storm signals for Calcutta has been successfully introduced. A special system for Bombay has also been continued as in former years. The daily time-signals for Calcutta are in charge of this office. The erection of a first-class meteorological observatory at Allahabad has not yet been completed. The Indian Meteorological Office has published among its Indian Memoirs the following:

F. Chambers, The Winds of Kurrachee.

S. A. Hill, Some Results of Meteorological Observations at Allahabad.

S. A. Hill, The Meteorology of the Northwest Himalayas.

11. The London Meteorological Council began with January, 1884, the publication of its Monthly Weather Report, which, although it is published very late in the year, yet affords encouraging evidence of the energy with which meteorology is studied in Great Britain. [Similar monthly weather reviews are now published by many important meteorological offices. We believe that the initial step in this direction was taken by the United States in 1872. Its monthly review as re-organized in 1873 by the present writer, has continued with praiseworthy thoroughness and promptness.]

12. The report of J. Y. Buchanan on the Physics and Chemistry, the Specific Gravity and Deep-Sea Temperatures, observed during the voyage of H. M. S. Challenger, has been published, and is reviewed by R. H. Mill. (*Nature*, xxx, p. 313.)

13. At the Health Exhibition, London, July, 1884, a meteorological conference was held. Papers were read by Dr. J. W. Tripe, on Meteorology and Health; R. H. Scott, on Equinoctial Gales, and also on Cumulative Temperatures, or Phænological Constants. (*Nature*, xxx, p. 351.)

14. The International Geodetic Congress, held at Rome in October, 1883, adopted resolutions recommending Greenwich as the initial meridian for all longitudes, and also Greenwich noon as the initial point of a universal hour and cosmopolitan date.

15. The International Meteorological Congress, held at Rome, 1879,

recommended the general acceptance of Greenwich meridian for the reckoning of longitudes.

16. The International Meridian and Time Conference, held at Washington October, 1884, has confirmed these and other recommendations, and unanimously recommends an international system of longitude and time based on the Greenwich meridian and mean midnight.

17. [In conformity with the above, the Chief Signal Officer has adopted for the use of the Signal Service the 75th meridian, or five hours west of Greenwich, as the uniform standard for the United States and for use in the Monthly Weather Review. For the International Bulletin the observations are made at Greenwich noon. The International Polar Conference has, we believe, not adopted any especial meridian for general use in the publications of the work done by its polar parties.]

18. Dr. Assmann has published the annual volumes of the meteorological observations for the Wetterwarte or weather observatory of the Magdeburg *Times*. It seems that he has been successful in inspiring the owner of this newspaper, Mr. Faber, with something of his own enthusiasm, the result being to establish a very completely organized observatory to which a number of subsidiary stations make reports, representing all of Saxony and its neighborhood. Everything is done in accordance with the recommendations of the International Congress and the best information of the present day. We note especially that the records with the Sprung barograph show the great advantage of continuous registers over those that record only every ten or fifteen minutes, or possibly every hour. (*Z. O. G. M.*, XVIII, p. 434.)

19. Dr. Assmann, on behalf of the Meteorological Observatory at Magdeburg, has undertaken the publication of a monthly journal for practical meteorology. This journal—the *Monatschrift*—is intended for local distribution among non-scientific readers; it treats of all matters in an elementary, popular manner, and is especially rich in everything that pertains to agriculture and hygiene, such as the temperature of the lowest air strata, excessive heat and frost, the distribution of rain. In this latter field good work has been done by establishing numerous rain-gauges throughout the neighboring countries, and an interesting study is in process on the influence of the Brocken upon the rainfall. [In this respect Dr. Assmann seems to be studying a problem similar to that which the Signal Office has undertaken in reference to Mount Washington.] (*Z. O. G. M.*, XIX, p. 201.)

Dr. Assmann at the close of the second year of his monthly journal for Practical Meteorology, has changed its title to *Das Wetter*, and carries it on now as a popular German monthly for world-wide distribution. Being also recognized as the popular organ of the German Meteorological Association, it has at once assumed a high importance. [The rapid growth of interest in meteorology in Germany is best realized by considering that within two years two new journals have thus been started under flattering auspices, and that lectures on meteorology are

now given in about twenty universities, whereas scarcely five gave any proper attention to the subject in 1883, when Mr. F. Waldo compiled the Signal Service Note on this subject.] (*Z. O. G. M.*, XIX, p. 287.)

The German Meteorological Association was organized on the 18th of November, 1883, at a meeting in Hamburg of about thirty of the most prominent meteorologists of Germany. At this meeting a temporary organization was effected, Dr. G. Neumayer being elected president. A simple form of constitution was adopted, and the first regular meeting appointed to be held at Magdeburg in September, 1884, at the time of the annual meeting of the German Scientific Association (Naturforscher-Versammlung). The formation of local branches is also encouraged, of which three have already been announced, namely, Hamburg-Altona, Berlin, Magdeburg.

Like the Austrian, so the German association proposed to hold but one annual meeting, but will publish a monthly journal as a means of stimulating the development of meteorology.

20. The first annual meeting of the German Meteorological Association was held in Magdeburg, September 19, 1884. The secretary, Dr. van Bebber, stated that the number of members was, at that time, 406; branch associations exist in Magdeburg, Munich, Berlin, Hamburg-Altona, and Rudolfstadt. Of the members, 361 are domestic and 45 foreign; 51 are employed in meteorology, 130 as teachers of various grades, 47 are meteorological observers, 21 physicians, 30 lawyers, 10 apothecaries, 71 manufacturers and merchants, 18 agriculturists, 20 military officers, 12 astronomers. The branch associations have membership about as follows: Magdeburg, 200; Hamburg-Altona, 43; Berlin, 92; Munich, 65; Rudolfstadt, not given. This last association was formed in 1880, but is now become a branch of the general association. A proposition is on foot looking to the eventual union of the journal of the German society with that of the Austrian, probably at the beginning of the year 1886. At present the German society maintains its own and encourages Dr. Assmann's journal, *Das Wetter*. [It is evident from the list given elsewhere that it will be very difficult to condense into one journal all the emanations from the numerous investigators of this most active scientific nation; but for the convenience of students it is to be hoped that we may have one or two, but not more, special meteorological journals in each language. It would seem that one in Russian, one in French, two in German, and two in English, one for Great Britain and one for America, with perhaps a third eventually for India and Australia, should abundantly answer the local needs of the respective communities and the general needs of science.] (*D. M. Z.*, I, p. 412.)

21. Of the German periodicals devoted more or less to meteorology we notice especially the *Wochenschrift für Astronomie, Meteorologie und Geographie*, published by H. J. Klein, of Cologne; *Der Naturforscher*, published in Berlin; *Humboldt*, a monthly journal for natural sciences,

published by Prof. Dr. G. Krebs; *Astronomische Nachrichten*, the well-known astronomical journal now published at Kiel by Professor Krueger; *Geographische Mittheilungen*, the well-known geographical journal now published by Professor Supan, at Gotha; *Hydrographische Mittheilungen*, published by the German Admiralty, Berlin.

22. Capt. N. Hoffmeyer and Dr. George Neumayer having agreed to continue conjointly the daily synoptic weather charts for the Atlantic Ocean and Europe, beginning with the 1st of December, 1880, this important work has therefore been kept up. The expenses are largely defrayed by the subscriptions of those interested in meteorology, and more such are solicited. The charts show the eastern half of North America, the West Indies, and the northern coast of Brazil, the whole of the North Atlantic, Greenland, Europe, and the western half of Siberia. They represent the condition of the weather in the morning about 8 A. M., or local time. The base chart is apparently a conical development on a scale about four times as large as that of the United States international map of the northern hemisphere, and three-fourths of that formerly adopted by Hoffinger; it therefore shows every station and every ship's report. If the British office publishes special charts for each day of the international polar campaign, from the 1st of August, 1882, to the 31st, then the German Government will probably supplement these charts by corresponding daily series for the South Atlantic Ocean. (*Z. O. G. M.*, XIX, p. 30.)

23. The Italian Meteorological Association, having its central observatory at the Royal College of Carl Albert, in Moncalieri, has continued to publish a monthly bulletin, which is considered as a second series, beginning with January, 1881; the first series being the monthly *Annuaire*, published by Ragona. The present bulletin is under the editorship of Denza, who has secured stations not only throughout Italy and the Alps, but also throughout South America. (*Z. O. G. M.*, XVIII, p. 357.)

24. The central office for Italian meteorology has continued to publish its magnificent series of large quarto volumes of Annales. These volumes are divided into three portions; the first contains reports on special work, such as Millosevich on rainfall, Ragona on the wind, Chistoni on magnetism and barometric comparisons, Ferrari on thunder-storms. The second portion contains synopses of the meteorological observations. The third portion contains the astronomical work at the Rome Observatory under Tacchini.

25. The Meteorological Institute of Saxony since 1863 has been a bureau of the Astronomical Observatory at Leipsic, but an important advance was made on the 1st of April, 1884, in the appointment of Dr. P. Schreiber, of Chemnitz, as director of the Meteorological Institute, which is now reorganized and placed on an independent basis in the Department of the Interior. Dr. Schreiber is well known by his works on meteorology and barometric hypsometry, and the new institution at

Leipsic has, under his management, already shown increased vitality and usefulness.

26. He has begun the publication of a monthly report in a slightly condensed form, but containing much appropriate and instructive matter, which is arranged in the following divisions: (*a*) Results by decades and months for 11 stations; (*b*) average variability of the weather in Saxony; (*c*) weather review for Europe; (*d*) normal weather in Leipsic for the month; (*e*) verifications of the predictions for the month given separately for each locality. There are several features in this weather review especially worthy of commendation; thus the use of decades in addition to the months is a step which has been for some time past adopted by the meteorological institutes of the Netherlands and Italy and the German Seewarte. These are more convenient than Dove's pentades, which are in fact only specially applicable to the rapid change in temperature. (*D. M. Z.*, I, 417 and 285.)

27. [The Signal Service in 1870 adopted a form which made it convenient to reckon by weekly averages from Sunday to Saturday throughout the year, and a number of tables of this kind were prepared; but very little was, however, given to the scientific world in this form; in fact, the weekly form was itself adopted almost entirely for executive reasons, and was replaced in 1881 by a much more convenient monthly form, in which the division and summation by decades is very easily made, although it seems improbable that it will ever be practicable to publish the enormous mass of signal service data in this extreme detail.]

28. Prof. M. Merino, well known as the author of a memoir on the climate of Madrid, has been appointed as director of the Observatory of that city, and has published with unexpected promptness the volumes of Spanish observations for the years 1876 to 1882, which publication had fallen in arrears, owing to successive changes since the death of the former director, Aguilar. The number of meteorological stations has been more than doubled during the past ten years and the outfit of instruments perfected. Most of the stations have means of observing solar radiation, terrestrial ground temperatures, evaporation, and wind velocity by Robinson's anemometer. The international forms for publication of climatological data have been adopted. (*Z. O. G. M.*, XIX, p. 340.)

29. Lieut. E. von Wohlgemuth communicates the general results of the Arctic expedition of the Austrian Government to the island of Jan Mayen in 1882–'83. He states that no difficulty seriously interfered with carrying out every point of the programme, everything being, in fact, much more favorable than had been anticipated. Only once did the minimum thermometer fall below —32° C.; the temperature most favorable for work was —10° or —15°, since with this temperature came a dryness and transparency of the air, and for it clothing could be selected that on the one hand protected from the cold and on the other was not so heavy as to interfere with outdoor labor or provoke troublesome per-

spiration. Absolute calms or the lightest breezes, up to 5 miles per hour, occurred only during one hundred and forty-one hours out of the six months September to February; during the other half of this year winds and storms prevailed so that the average wind velocity was 20 miles per hour. This very stormy weather necessitated extraordinary care with reference to the security of the building. The first part of the polar night belonged to the pleasantest period of the residence on Jan Mayen; it brought cold dry weather and outdoor sports, such as sailing with ice-boats, running with snow-shoes, skating, and many other new, exciting, and refreshing changes in the otherwise monotonous occupations. The health of the whole party was excellent; neither scurvy, nor catarrh, nor frost-bites were experienced. The prevailing winds were east-southeast and south-southeast during the prevalence of cyclonic storms, some of which occasionally became almost stationary low pressures. During such winds the temperature rose to an average summer heat, even in the midst of winter, and the snow melted rapidly everywhere. The monthly wind summary shows a slight percentage of the southwest winds that prevail in more southern latitudes; these exceptions are explained as due to the formation of cyclones whose front sides only attained complete development. On the other hand, the higher currents were almost exclusively from the southwest, so that even the cirrus clouds, almost without exception, came from this direction. Of the cyclones that passed over Jan Mayen, only the front was well developed. The greatest wind force was nearer the outer limit of the whirl than is the case in ordinary tropical cyclones. The storms did not suddenly stop on the advent of the lowest pressure, but after the passage of the center still continued with all vigor. Frequently in the region of a barometric depression light winds prevailed, the barometer was fluctuating, the wind and sea were calm, and the brightest sunshine continued for many hours. (*Z. O. G. M.*, XVIII, p. 441.)

30. The International Polar Conference held at Vienna April 17, 1884, arranged for the publication and discussion of the vast mass of observations accumulated by all nations during 1882–'83. The chiefs of nine expeditions were present. Each country will publish its own results in full. The conference will publish the general results through experts, to whom each question is referred. The protocol of the conference fills the last of the Mittheilungen published by the Polar Commission.

31. The American expedition to Lady Franklin Bay was rescued from its position at Cape Sabine in June, 1884; only six survived out of the original twenty-five. The objects of the expedition were fully accomplished, the observations and explorations being conducted with remarkable success for two years, and the health of the party was perfect the whole time. Lieut. A. W. Greely with perfect success accomplished a most remarkable polar journey in the way of a retreat of the whole party southwards to Cape Sabine, at which place, however, the American rescue party of 1883 having been wrecked, Greely found no pro-

visions awaiting him as had been originally contemplated, and, in consequence, nineteen members of the party died during the early part of 1884.

In a general way, Lieutenant Greely reports the lowest temperature —66° Fahrenheit; the tidal flow came from the north; currents in the bay coming from the north were two degrees warmer than coming from the south; the tidal range was 8 feet; there was no polar current in the open sea to the north.

The line of perpetual snow on Mount Arthur he places at 3,500 feet. (*Nature*, XXX, p. 438.)

32. N. Ekholm has published the preliminary account and statistical summary of the Swedish International Polar Expedition to Spitzbergen. Observations began August 22, 1882; an anemometer was fixed on the mountain top 800 feet above the ocean. The aurora borealis occurred every night up to March 25, when the sunlight interfered. The thermometers in shelter were compared with the sling-thermometer until, by frequent breakages, the observers were forced to construct an equivalent rotation machine. The station was closed August 25, 1883. (*Nature*, XXIX, p. 263.)

33. The Danish Meteorological Institute has published the summary of the Danish International Polar Expedition to the Sea of Kara.

34. Preliminary reports containing the monthly means and miscellaneous notes have been published for the two German Polar Stations, namely, at Royal Bay in South Georgia, and at Kingawa Fjord in Cumberland Gulf, Baffin's Land. (*D. M. Z.*, I, p. 144.)

35. A. von Danckelman publishes the records for 1882–'83 at the Danish International Polar Station, Godthaab, in order that by comparison one may better decide to what extent this was a normal year. (*D. M. Z.*, I, p. 163.)

36. Lieut. J. Lephay, chief of the meteorological work of the International Polar Station at Cape Horn, occupied by the French Government, publishes a summary of the climate at their station, which was on the east side of the peninsula Hardy, in a portion of Orange Bay three French miles from the Pacific and thirty-five northwest from Cape Horn. The daily period of pressure was quite perceptible, the maximum being 8 P. M. and the minimun 2 P. M. The diurnal periodicity of the wind force was very large, maximum being at 2 P. M. and minimum at 1 A. M.; the prevailing wind direction was from west-southwest. (*Z. O. G. M.*, XIX, p. 131.)

37. H. P. Dawson, in charge of the English International Polar Station at Fort Rae, reports that the winter of 1882 and 1883 was very mild. In January, 1883, a remarkable epidemic influenza was reported among the Indians in the far northwest, and spread southward to Forts Simpson and Rae, attacking every one in a mild form. (*Nature*, XXVIII, p. 371.)

38. [If this can be traced farther south in connection with the cold

northwest winds that sweep down over Manitoba and the United States, we shall have to suspect that these epidemics are due to minute organisms carried by the air, possibly in its upper currents, from some equatorial region, some such mass of air as is thrown by a hurricane out of its normal route, or is carried up over the Pacific and thrown against the Alaska coast only to come down upon the east slope of the Rockies as a dry wind, or such as is sometimes drawn from Northern Russia over the Polar Sea, only to flow southward as a cold norther over British America. Thus epidemics and spores, insects, seeds, migratory birds, volcanic dust, &c., are distributed over the world by the winds obedient to a complication of rigid laws that invite human energy to unravel them.]

39. Among the scientific results noted in his preliminary report to the Royal Society, Capt. H. P. Dawson states that Fort Rae is located at the southwest extremity of a peninsula that juts out from the northeast shore of a long gulf running in a northwest direction for more than 100 miles from the northern shore of the Great Slave Lake; it is therefore almost entirely surrounded by water. The greatest magnetic disturbance occurred November 17, 1882. Whenever an aurora occurred in the zenith there was a rapid decrease in vertical and horizontal magnetic force. Auroras suitable for measurement of altitude were rare and lasted only a few seconds; the wind was usually in a southeast or northwest direction; when the former prevailed the upper clouds showed a northwest current. (*Nature*, XXIX, p. 247.)

40. A. S. Steen gives a preliminary account, in *Nature*, of the activity at the Norwegian circumpolar station at Bossekop. Auroras were seen every night, and accurate measures were taken in conjunction with others by Dr. Tromholt, at Kautokeino. The thermometer shelter conformed to Professor Wild's model. Psychrometer and dew-point apparatus were frequently observed together. The chemical determinations of atmospheric moisture were not satisfactory. (*Nature*, XXVIII, p. 567.)

41. The Russian Government decided to maintain a meteorological station for some time at Sagastyr on the Lena. The average temperature of February, 1884, was -33° C., or 8° warmer than 1883. Strong winds were specially frequent during the last year.

42. A. E. Nordenskiöld, in letters to Mr. Dickson, gives an account of his journey into the interior of Greenland, starting from Disco Bay on July 3, 1883. The ascent to an elevation of 800 meters took place quite rapidly; after that more slowly, until the height 1,492 meters was reached on July 22. From this point his Lapp escort went eastward six days, accomplishing about 115 kilometers, reaching a height of 2,000 meters at a distance about 300 kilometers east of Disco Bay. The whole region was, of course, a uniform glacier of ice and snow, with occasional lakes of melted-snow water. (*Nature*, XXIX, pp. 11–39.)

43. Dr. H. Mühry, of Göttingen, in reference to the great problems in meteorology, states that he is himself most impressed with the impor-

tance of understanding the subject in its widest details as terrestrial physics, and that the study of the equatorial region should be taken up in full force as this calm belt is the basis and motive of the whole atmospheric circulation. Whatever may be said as to the importance of weather predictions or cyclone theories or the tracks of cyclones or anti-cyclones or climatic and other applications, yet we must avoid the mistake of treating meteorology from too local or empirical a point of view. (*D. M. Z.*, I, p. 407.)

44. [The study of the northers of the Mississippi Valley and Gulf of Mexico showed as long ago as 1871 that a very slight diminution of pressure in the tropical regions frequently gives occasion for a southerly flow of cold air, which, piling up against the northern side of the Mexican Cordilleras, produces a great area of about 8,000 feet deep of cold, cloudy, and rainy weather, out of which gradually develops a storm that subsequently moves northward as a hurricane over the United States. And as a generalization it is suspected that the hurricanes originating in the Middle Atlantic, whether on the coast of Africa or of South America, owe their origin in a similar way to an inflow of cool air into a region where higher temperature, increased moisture, and the formation of clouds having strongly heated upper surfaces, had conspired to produce an uprising tendency. In this way it became proper to speak of the equatorial region as that whose heat was the fundamental cause not only of the general atmospheric circulation, but of storms and other special phenomena, and in this way we were prepared for Köppen's demonstration, in 1874, that the solar heat with its variations more directly affected the equatorial regions of the earth whence its influence more slowly spreads to distant latitudes. Now that the International Polar Commission has given us such a precious collection of data relating to the higher latitudes north and south, it is undoubtedly incumbent upon meteorologists to urge a similar and far more thorough crusade into the torrid zone, where we need a large number of new stations on land and sea maintained for the whole of, at least, one sun-spot period. The continuous observations needed in tropic seas could be provided for if the principal nations of the globe would inaugurate, each in a selected district of the ocean in the torrid zone, an exhaustive study of its hydrography, fauna, and ocean currents simultaneous with the marine meteorological observations.]

45. Dr. M. Miles, as director of the agricultural experiments at Houghton farm, Orange County, New York, has, since 1881, carried out several distinct lines of investigation mostly relating to animal and vegetable nutrition. The proprietor of the farm is Mr. Lossing Valentine, a rich merchant of New York, who desires in this way to contribute something toward the progress of American agriculture. The work on the connection between meteorology and agriculture is in the hands of Prof. D. P. Penhallow, who, among other things, issues daily bulletins of local weather predictions, for which a verification of 98 per cent. is

claimed. The general manager of the farm is Maj. H. E. Alvord. (*Nature*, XXIX, p. 238.)

46. Dr. C. Lang, of Munich, describes the establishment of a new station on the Wendelstein, where observations began on the 8th of October, 1883. Up to this time the Bavarian weather bureau had no station higher than the Hohenpeissenberg (994 meters), but has now taken advantage of the fact that a house for tourists was about to be established on the Wendelstein (altitude 1817.4 meters). This mountain is 1,062 meters above the valley below it, and, therefore, comparatively isolated and steep. In regard to the instruments with which the station is furnished, we notice that the thermometer shelters are placed on the east and west sides of the building, because the north side is inconvenient. The shelters are, however, one meter distance from the respective walls. Within these shelters are maximum and minimum thermometers and a thermograph manufactured by Steppacher. The station also has a rotation psychrometer made by Rung, of Copenhagen. For the wind force no instrument is used, but estimates are given on the 0–12 scale of Beaufort. It is hoped to establish two self-registering thermometers, one at the top the other at the bottom of the mountain, and for this purpose probably those manufactured by Richard, of Paris, will be selected. (*Z. O. G. M.*, XVIII, p. 458.)

47. The Meteorological Office of the Marine Observatory, at San Fernando, in January, 1884, began the issue of daily weather charts and storm warnings for the Spanish coast.

48. The Italian Meteorological Office has established a mountain station, at an altitude of 2,160 meters, upon Mount Cymone.

49. The Melbourne Observatory publishes a monthly record of meteorology in Victoria. Attention is called to the work being done in Australia, and also to the necessity of more care in reference to certain thermometer records. (*Nature*, XXX, p. 126.)

50. The Meteorological Council of London, having decided to close the primary self-recording observatories at Glasgow, Armagh, Stonyhurst, and Falmouth, on account of the expense, the authorities at the latter place have forwarded a remonstrance, strongly supported by Prof. J. C. Adams, of Cambridge. These observatories have been in operation since 1868, and if other nations follow the example of England in this respect we shall never attain satisfactory knowledge of local peculiarities in climate or meteorology.

We are, however, glad to have to add that the foundation stone of the new meteorological observatory at Falmouth was laid August 12, 1884; this was in consequence of a new agreement with the Meteorological Office, which will continue its apparatus and work under more favorable auspices. (*Nature*, XXX, p. 249.)

51. Frequent notices appear in *Nature* of the work done on the observatory at Ben Nevis; among others we note that Mr. Omond, at the summit, is conducting a series of observations with a hygrometer of

novel description especially designed by Professor Chrystal; ordinarily the wet bulb and dry bulb read together, but occasionally the clouds clear, the sun shines very hot, and the air acquires a marvelous dryness calculated to test the capabilities of this instrument. (*Nature*, XXIX, p. 342.)

Dr. C. L. Wragge gives a description with illustrations of the meteorological observatories on and near Ben Nevis. (*Nature*, XXVII, p. 487.)

The observatory on Ben Nevis is supported by private subscription mostly, and it is hoped that means will be forthcoming to maintain observations during the winter of 1884–'85. (*Nature*, XXX, p. 179.)

A general summary of the meteorology of Ben Nevis from June, 1881, to June, 1884, is given by Buchan. (*Nature*, XXX, p. 336.)

During the winter of 1884–'85, new rooms and conveniences for self-registering wind instruments will be available, over £2,000 sterling having been spent on the arrangements for observers and visitors to the summit of Ben Nevis.

52. Dr. W. Doberck, director of the new English observatory at Hong-Kong, has taken active steps to carry into effect the system of meteorological predictions and observations promised by inspector-general of Chinese customs, Sir Robert Hart, as long ago as 1873. The instruments were purchased at that time, but have been either injured or unpacked, and are of course useless. Doberck has compared them and proposes to establish 33 stations, mostly on the Chinese coast, whose observations shall be published annually, while a daily system of telegraphic storm warnings is maintained for the benefit of commerce. (*D. M. Z.*, I, p. 86.)

53. The activity of the Hong-Kong Observatory commenced January 1, 1884, with tri-daily meteorological observations, daily and monthly weather reports. Weather telegrams are daily received from the treaty ports of China, from Luzon, Japan, Vladivostock, and Tonquin. Self-registering meteorological observations began April 1; a time-ball will be dropped after January 1, 1885. An excellent illustrated description of the observatory is given in *Nature*, XXX. It is suggested that all observations that can be made available for the formation of a meteorological system for that section of the world be concentrated by daily and monthly reports at Hong-Kong as the most important center. This, however, should not in the least interfere with the remarkably successful work going on in Japan.

54. The Geographical Society of Lisbon having maintained a temporary meteorological observatory near the highest point of the Serra da Estrella at an altitude of 1,855 meters and a degree and a half east of Lisbon, the results of the first year of observation have been reported by A. C. da Silva. Among the principal results are the following: Maximum pressure at noon, minimum at 5 A. M., while for Coimbra (altitude 141 meters) we have maximum at 10 A. M., minimum at 6 P. M. As to temperature, Estrella has maximum at 2 P. M., minimum at 4 A.

M., while Coimbra has maximum at 2 P. M., minimum at 5 A. M. The wind velocity for Estrella has a maximum 30.5 kilometers per hour at 1 P. M., and a minimum 20.2 at 9 P. M. The maximum wind velocity was 65 kilometers per hour at 3 P. M. on August 17, 1882. The prevailing winds were west and northwest; the average daily evaporation was 15.0 ^{mm}; the heights and forms of clouds were regularly observed; determinations of the altitude and the altitude of cumulus clouds under which thunder-storms were in progress, gave from 5,450 to 6,750 meters. (*Z. O. G. M.*, XIX, p. 423.)

55. Prof. J. M. Pernter communicates some of the latest results of observations on the summit of the Obir (2,048 meters), which show the following features:

1. The daily temperature curve is above the mean value for only one-third of the whole day, and attains a maximum at about 2 P. M. in January and 4 P. M. in August.

2. The amplitude is the same for all months of the year, and depends only on the quantity of sunshine.

3. It must be remembered that the thermometers are on the south side of the observatory in a space inclosed by a double board screen; but provision has been made for a perfect circulation of air, and the radiation of the screen is cut off by another screen of sheet-tin, and although all this is not at all satisfactory, and some local influence is probable, yet it is safe to say that the maximum occurs later at these high altitudes, in confirmation of which Pernter quotes ten days of hourly observations on Mount Ararat (3,333 meters).

4. Although in Vienna the west wind has an enormous preponderance both in frequency and total movement, yet on the Obir the southeast wind has a decided preponderance, and on the Säntis, as Billwiller has shown, the southwest wind prevails, and the southeast is the least frequent; must we not, then, conclude that the summit of the Obir lies within the influence of the Italian area of low pressure, and that it is too low to reach up into the southwest current that probably prevails above?

5. The comparison of the sunshine register on the summit with that at Klagenfurt, near the base of the mountain, shows at the summit a maximum of sunshine between 10 and 11 A. M., but at Klagenfurt about 2 P. M.

6. The total sunshine on the summit exceeds that in the valley from October on throughout the winter, but during the summer months Klagenfurt exceeds the summit; the number of days without sunshine is about the same. On fourteen days the summit had no sunshine, while the base had from one to six hours; in general, perfectly sunny days are more frequent on the summit than in the valley. (*Z. O. G. M.*, XIX, p. 331.)

56. Rudolph Hottinger-Goldschmidt was born 4th of May, 1834, and lived since his fourth year at Zurich, at which place he died September

30, 1883, after a short illness. Having graduated from the Swiss Polytechnic School, he was engaged until 1871 in railroad and topographic surveys, in which year he entered into the business of his father-in-law, the well-known mechanician, Goldschmidt; after his death, in 1875, Hottinger entirely conducted this business, in association with Dr. Koppe, until the latter was appointed professor at Brunswick. The accurate instruments made by this firm are well known throughout Switzerland, especially the so-called Goldschmidt aneroid barometer, which in its improved form has in Europe rapidly displaced all other aneroid and even mercurial barometers for accurate and convenient use in field surveying. (*Z. O. G. M.*, XVIII, p. 465.)

57. Baron Vice Admiral von Wüllerstorf-Urbair, born January 29, 1816, at Trieste, died August 10, 1883, at Vienna. By his command of the frigate Novara on a scientific navigation of the globe, 1857 to 1859, von Wüllerstorf became well known to the scientific world. He had previously, from 1839 to 1848, been the director of the Naval Observatory at Venice and professor of astronomy at the Naval Academy. (*Z. O. G. M.*, XVIII, p. 361.)

58. Sir Edward Sabine, born at Dublin, October 14, 1788, died near London, June 26, 1883. At the age of fifteen, after graduating at the military schools, he entered the English Artillery and attained to the rank of lieutenant-general in 1850, and general in 1874. His scientific activity began in 1818, when he became a member of the Royal Society of London, and was appointed as astronomer to the polar expedition under Sir John Ross. Until 1827 his principal activity related to meteorology and geodesy, but from that time on his life became more completely devoted to terrestrial magnetism, which subject had, however, attracted his attention and activity since 1821. His whole work in this field has marked an epoch in the history of terrestrial physics, and has also been of the greatest practical value to navigation. The colonial observatories of Great Britain were for many years under the supervision of Sabine, who reduced and published the results. [It is not improper to add that in all this work Lady Sabine has been his most active assistant and colaborer.] (*Z. O. G. M.*, XVIII, p. 362; *Nature*, XXVIII, p. 218.)

59. Prof. M. Kowalski, born August 15, 1821, at Dobrzyn, Russia, died July 9, 1884. In 1850 Kowalski was made assistant astronomer of the University of Kasan, and in 1854 director of the Observatory. His memoir on atmospheric refraction shows a thorough knowledge of the modern theory of distribution of temperature in the air.

60. Prof. J. F. J. Schmidt, born October 25, 1825, in Oldenburg, Germany, died February 7, 1884, at Athens. Schmidt became director of the Observatory at Athens in December, 1858, and his activity in advancing our knowledge of the climate of Greece is remarkable, the more especially when we consider his great labors in astronomy.

61. L. J. Kapeller, born at Gratz July 20, 1804, died September 14,

1883, at Vienna. For many years Kapeller's name has been well known among meteorologists in connection with the beautiful and precise instruments that have issued from his workshops, and which are widely used, not only in Austria and Germany, but also in France, England, Brazil, Turkey, and America.

62. N. H. C. Hoffmeyer, born June 3, 1836, served as a military officer, but resigned (1866) on account of rheumatism, since which time he has devoted his life to meteorology. In 1872 he founded the Meteorological Institute of Denmark. He died suddenly on the 16th of February, 1884. (*D. M. Z.*, I, p. 88.)

63. Prof. Hugo von Schoder, born November 11, 1836, became director of the meteorological stations at Würtemberg in 1865, and died April 11, 1884. (*D. M. Z.*, I, p. 171.)

64. Prof. Dr. George von Boguslawski, born at Breslau, December 7, 1827, died May 4, 1884, at Berlin. Since 1874 as the editor of the *Annalen* or *Hydrographische Mittheilungen*, and for many years as secretary of the Berlin Geographical Association, he has done an important work for Germany.

65. Peter Merian. On February 8, 1883, this honored man died at an advanced age in Basle. His life has been given to the advance of Switzerland in many scientific directions. In 1826 as a member of the Swiss Society of Naturalists he began a series of meteorological observations at Basle, which he did not relinquish until fifty years later. (*Z. O. G. M.*, XVIII, p. 467.)

66. Prof. A. H. Guyot, born at Neuchatel, September 28, 1807, died at Princeton, N. J., February, 1884. His investigations on the glaciers, his hypsometric work in the United States, his meteorological tables, and other instructions to observers for the Smithsonian Institution, his works on physical geography and climate, have made his name well known in meteorology.

67. Thomas Plant, who has maintained uniform meteorological records for forty-four years at Birmingham, England, died September, 1883, aged sixty-four.

II.—(*a*) General treatises, Meteorology, Climatology, Physics, History; (*b*) Instruction; (*c*) Weather predictions and verifications.

68. Prof. J. Hann has published, as one of the series of Allgemeine Erdkunde, a volume on The Earth as a Planet (Weltkorper), which is obtainable in separate form. This volume is rich in recent results of physical study; the form of the earth, the force of gravitation, the magnetic phenomena and auroras, and the atmosphere and glacial climate and the ocean are especially well treated.

69. R. H. Scott has compiled an Elementary Meteorology, which has also been translated into German by W. von Freeden and simultaneously published at Leipsic. It is divided into two portions, the first

treating of the observations and individual phenomena; the second part treats of the distribution of these phenomena over the earth's surface. The work claims only to reproduce the best views of the students of the present day, and therefore introduces but little which can be called individual. It is undoubtedly one of the best works at present available in English, but contains some important defects that will, we hope, be remedied in a treatise by Ferrel on Recent Advancement in Meteorology, about to be published by the Army Signal Office for the use of its observers.

70. Hann has published a second edition, in two thin volumes, of Jelinek's Introduction to Meteorological Observations; he has added several important tables and the description of new important instruments.

71. Prof. P. G. Tait has published two treatises, on Heat and on Light, respectively, which, as might be expected from this eminent author, present the best view of the present condition of each subject; the references to meteorological applications give these an especial interest in this place.

72. Excellent elementary books on physics have been published by Profs. J. D. Everett, of Glasgow; J. Trowbridge, of Cambridge; W. A. Anthony and C. F. Brackett, of Princeton. That of Professor Trowbridge is especially recommended by its thorough fidelity to experimental instruction. The chapter on the atmosphere, barometer, &c., is most admirable for the younger students of meteorology, the experimental or laboratory side of which science is still susceptible of great development, as is shown especially by the works of Vettin and Kiessling, elsewhere more fully noted.

73. A. Woeikof, of St. Petersburg, has published a treatise on the climate of the earth, especially of Russia. Although in the Russian language, and therefore evidently intended especially for the use of the Russian universities, this work is of much wider interest because of the activity of the author in many branches of statistical meteorology. His work is entirely independent of that of Hann, but it has a very similar range, and in respect to charts and illustrations is much richer. There is, however, very little repetition in the two works. The originality of Woeikof appears in every chapter. Undoubtedly the introduction of the work into the Russian universities will greatly stimulate the education of meteorologists in that country and place it in advance of any other nation except possibly Germany in the recognition of this science as a branch of university study. (*Z. O. G.*)

73′. [We hope that the progress of meteorology, thus stimulated by the great work of Woeikof, will not meet with the adverse fortune which was indicated by a recent imperial decree of August 4, 1884, by virtue of which the scientific works of Darwin, Agassiz, Huxley, Lubbock, Adam Smith, Spencer, and many others have been proscribed; circulating libraries will not deliver them to their subscribers, and book-dealers will not sell them.]

74. Dr. A. Woeikof contributes a valuable study on the climate of Eastern Siberia, showing that one part of Eastern Siberia is entirely in the monsoon region of Eastern Asia, while the other portion can be considered as the northern limit of this same monsoon region. Among other things he shows (1) for the greater part of Eastern Siberia that since the greatest cold occurs with calms and feeble winds, therefore the valleys and lowlands are in winter colder than the high lands; (2) the temperature of isolated hills is still higher; (3) the cooling of the valleys is so long continued and intense that even the temperature of the year is lower there, as proved by the observed temperature of the ground; (4) the depth of the frozen earth is greater in the valleys than on the neighboring highlands, probably also greater than on the high mountains; (5) in the Tundra of the extreme north the winter is warmer than in the valleys of the forest regions of the south, probably because the strong winds prevent the long stagnation of the coldest low stratum of air. (*D. M. Z.*, I, p. 443.)

75. The Austrian Hydrographic Office has published a hand-book of oceanography and maritime Meteorology, in which the separate chapters are composed by distinguished Austrian scholars; the whole forms a remarkable monument to the industry of the authors and to the progress that is being made in everything that relates to the ocean and its navigation. The first division of these two large volumes relates to the physiography of the sea, including instruments for measuring the depth and the currents, the waves, the chemical constituents, and a summary of the results of all the work done in these departments. The second division, on maritime meteorology, occupies about 400 pages, and is compiled by Prof. F. Attlmayer, of the Naval Academy. (*Z. O. G. M.*, XXX, p. 349.)

76. Prof. H. Mohn gives a summary of the climate of Norway, based principally upon recent observations conducted in a uniform manner with well-verified instruments. The altitudes for the stations seem generally to have been determined barometrically. A permanent barometric minimum exists southwest of Iceland, and another, not so deep, in the Norwegian Sea. From October to April a maximum prevails over the southwestern part of Norway. From May to September in Southwestern Norway a minimum exists. The isobars, like the isotherms, show a great tendency to follow the trend of the coast. (*Z. O. G. M.*, XIX, p. 145.)

77. Dr. C. Lang, of Munich, publishes in the fourth volume of Observations at Bavarian stations an exhaustive monograph on the climate of Munich, a work so complete that scarcely another can be found to compare with it. The observations extend from 1781 to 1880. Among the numerous tabular and statistical results, Dr. Lang occasionally introduces matter of general interest, such as his discussion as to what constitutes a raw and unpleasant climate.

78. [In regard to this we are of the opinion that ordinary meteorologi-

cal statistics will afford very little satisfaction. The sensations which human beings call "raw," "harsh," "depressing," &c., are subjective, and are compounds of several factors, such as temperature, moisture, wind, sunshine. Moreover, a locality that offers a few hours of such raw climate every day is not likely to be detected by observations at three hours only. The meteorologist is primarily interested in the physics and mechanics of the atmosphere, not in its influence on human sensations; that belongs to hygiene and demands a special apparatus and observations, a fine example of which is to be found in the work on subjective climate undertaken by J. R. Osborne, of Washington, from 1875 to 1877.] (*Z. O. G. M.*, XIX, p. 240.)

79. Pschrewalski's observations in Thibet have enabled him to locate the region of the sources of the Hoang Ho as that to which penetrate both the southwest monsoon from the Indian Ocean and the southeast monsoon from the Pacific coast of China. He also establishes the diurnal and annual variations of temperature, the former being remarkably large, amounting in some cases to from 20° C. at the midday maximum to −30° C at the morning minimum. Very interesting dustwhirls were observed and sketched. The transportation of dust by strong winds fully confirms Von Richthofen's theory of the formation of the loess. (*Z. O. G. M.*, XVIII, p. 303.)

80. Prof. J. Partsch, of Breslau, contributes a summary of our knowledge of the climate of Greece, based largely on the extensive collection of data made by the late Prof. J. F. J. Schmidt. (*Z. O. G. M.*, XIX, p. 473.)

81. Lehmann has compiled a complete list of the literature relative to the meteorology of Thuringia; he takes as his starting point the titles given by Hellmann. Similar works for many other sections of the world are desirable.

82. Zöppritz has brought together the meteorological results of a number of expeditions by Americans and others to the Central American regions. (*D. M. Z.*, I, p. 362.)

83. A. Angot, of Paris, has published a valuable study on the climate of Algeria, especially the temperature, pressure, and rainfall. The mean temperature for the year varies from 17.7 C., on the northern coast, to 21.1 C., on the southern border, namely, at the limit of the Sahara, in latitude 34°.1. The monthly ranges are as follows: On the coast, a minimum in January (11.4) and maximum in August (25.0); on the southern border, a minimum in January (10.4) and maximum July (34.1). We see from this that the temperature increase, especially in summer, as we proceed southward, is due not to latitude but to the continental peculiarities of the soil, the cloudless sky, and the direction of the wind. (*Z. O. G. M.*, XIX, p. 64.)

84. Dr. W. Köppen collects together the date of first and last rains at various points on the southwest coast of Africa as recorded in various years from 1874 to 1883. The beginning of the rainy season varied from

the 24th of July to 12th of October; the last rain is recorded at dates between the 1st of May and 8th of June. (*D. M. Z.*, I, p. 287.)

85. A. von Danckelman, as a member of the expedition of the International Congo Association, has returned to Europe with a series of meteorological observations for fifteen months on the west coast of Africa. He reports that the barometric changes were quite slight, the yearly range being 12^{mm}. No perceptible change in pressure occurred during the occurrence of the tornadoes peculiar to that coast. The rainy season is from April to November, during which numerous short, heavy thunder-storms precipitate a great quantity of rain, the heaviest being 102^{mm} in two hours. The thunder-storms come from the northeast; the surface wind blows from the point where the thunder-storm is. During the dry season the natives set fire to the grass-covered plains; these fires continue for months and have an important meteorological influence; the air is always full of smoke; great cumulus clouds and occasional lightning form over the burning regions, which cover many thousand square miles. The most remarkable phenomenon in the valley of the Congo is the frequent occurrence at night-time of a strong southwest wind; it begins soon after sunset and occasionally lasts until the early morning hours. (*Z. O. G. M.*, XIX, p. 88.)

86. The Physical Society of London has republished the scientific papers of J. P. Joule. The present first volume contains about 100 papers, many of them bearing on questions of the utmost importance to meteorology.

87. [We have now accessible reprints of the scientific papers of Sir William Thomson, Professor Stokes, Joule, Helmholtz, Kirchoff, and many other scientific names of living men. To meteorology, however, nothing would be more acceptable than a reprint of the meteorological papers of Joseph Henry, William Redfield, and James P. Espy. Will not some American scientific association do for us what the Physical Society has done for England?]

88. Dr. G. Hellmann has published his Repertorium of German Meteorology, in which he gives a very complete bibliography of the publications, discoveries, and observations made by Germans in the field of meteorology and terrestrial magnetism down to the end of the year 1881. Holding himself to a very strict understanding of the word "German," Hellmann has omitted the productions of Germans not citizens of Germany, and we especially miss the publications of German scientists in Austria, Switzerland, Russia, and elsewhere. Hellmann's work is divided into four principal sections: First, a catalogue by authors; second, subject index; third, index of stations and meteorological data; fourth, a historical sketch of meteorological progress in Germany.

89. [It was perhaps only by holding closely to this restriction that Hellmann was able to finish his large work in so short a time and present it as a realization of a single idea. But as has been remarked, one cannot but feel in using it at every moment that there is here a mass of

broken threads which need to be completed by making a similar collection of not only the remaining German, but all other meteorological literature. General W. B. Hazen, having decided that in view of the importance of the subject the Signal Office should complete the index to meteorological literature already in its possession in the shape of a large card catalogue, has solicited contributions of titles from all interested in the subject, and has appointed Mr. C. J. Sawyer as bibliographic expert to prepare the work for publication. The office will also make a special examination of various important libraries, serials, and other sources. As this work is, properly speaking, only a hand-book for the use of working meteorologists, it has been deemed most desirable to finish it in a short time without incurring such delay as might be needed to prepare a work of bibliographic elegance. Consequently the majority of the titles will be taken from Reuss, Poggendorf, the Royal Society, Hellmann, Symons, and other authorities without directly consulting the volumes themselves. It is expected that the work will occupy two volumes containing forty or fifty thousand titles in all, and that a first part will go to press early in 1886.]

90. Prof. Frank Waldo, of Washington, in a short note on the study of meteorology in Europe, shows that in 1883 out of thirty-eight German universities only fourteen had established special chairs for this study. In respect to this Dr. Köppen remarks that probably this neglect had already been partially rectified by 1884. The following is a list of those who are more or less devoted to instruction of this class (*D. M. Z.*, I, p. 148):

University of Berlin; Dr. Thiesen.

Technological School at Brunswick; Dr. H. Weber.

University at Czernowitz; Professors Supan and Handl.

Technological School at Darmstadt; Dr. Göbel and Prof. E. Dorn.

Technical School at Gratz; Professor Wilhelm.

University at Halle; Professors Knoblauch, Overbeck, and Cornelius, and Dr. Lehmann.

University at Heidelberg; Professor Kopp.

University at Innspruck; Professors Torre and Pfaundler, and Dr. Tollinger.

Polytechnic School at Carlsruhe; Professor Sohncke.

University at Königsberg; Professor Zöppritz.

University of Leipsic; Professor Bruns.

University of Rostock; Professor Mathiessen.

Polytechnic School at Stuttgart; Professors Dietrich and von Schroeder.

University at Vienna; Professors Hann and Simony.

High School at Zurich; Dr. Weilenmann.

The following have since been announced:

University of Giessen; Prof. H. Hoffmann; Dr. Frome will begin in 1884.

University of Berlin; Dr. Glan.
Agricultural School at Berlin; Professor Bornstein.
Polytechnic School at Brunswick; Dr. Pattenhausen.
Academy of Forestry at Eberswalde; Professor Müttrich.
University at Freiburg, Bavaria; Dr. K. R. Koch.
University at Göttingen; Dr. H. Meyer.
University at Kiel; Dr. Karsten.
University at Marburg; Professor Fischer.
The High School at Munich; Dr. Lang and Professor Ebermayer.

91. [The following American colleges include meteorology and climatology in their general or special courses:
Harvard University, Cambridge; W. M. Davis.
Massachusetts Institute of Technology, Boston; Prof. W. H. Niles.
Yale College, New Haven; Prof. E. Loomis.
Corcoran School of Science, Washington; Profs. C. Abbe and F. Waldo.
Michigan University, Ann Arbor; Prof. M. W. Harrington.
Brown University, Providence; Prof. W. Upton.
University of Iowa, Iowa City; Prof. G. Hinrichs.
Haverford College, Haverford, Pa.; Prof. P. E. Chase.
Colorado College, Colorado Springs; Prof. F. H. Loud.]

92. The very hopeful condition of the study of meteorology in England is evidenced by the following subject announced for the Adams prize to be adjudged in 1885: Investigate the laws governing the interaction of cyclones and anticyclones on the earth's surface. In order to give precision to this the following suggestions are given to the examiners: An infinite plane has a surface density $\frac{g}{2\pi}$ (where g is gravity); on one side of it is air in equilibrium, the density of which must diminish according to the barometric law as we recede from the plane. The system revolves as a rigid body, about an axis perpendicular to the plane, with a constant angular velocity ω.

If one or more vortices with a revolution either consentaneous with ω (cyclones), or adverse thereto (anticyclones), be established in the air, investigate their motions. It may be well to consider the axes of the vortices either straight or curved, and perpendicular or inclined to the plane. If possible, pass to the case in which the vortices exist in the atmosphere surrounding a rotating globe. (*Nature*, XXIX, p. 94.)

93. Prof. W. J. Beal, of the State Agricultural College at Lansing, Mich., in his address on the needs of agriculture before the American Association for the Advancement of Science, says that if specific warnings of the weather had been given during the harvest of 1882 most of the wheat might have been safely housed and the farmers of Michigan saved from a loss of a million dollars. (*Nature*, XXVIII, p. 618.)

94. H. F. Blanford gives an illustration of the general character of long range weather predictions by quotations from the India Gazette,

June 2, 1883, wherein he gives reasons for believing that the prospects for sufficient rain in India and Bengal during the rest of the season were wholly favorable. This and subsequent predictions in July and August were based upon the knowledge of snowfall in the Himalayas. (*Nature*, XXIX, p. 77.)

95. C. L. Madsen, in the interest of meteorology and European weather prediction, urges the importance of the proposed transatlantic cable, whose route will be through Thurso, the Faroes, Iceland, Julianshaab in Greenland, the Straits of Belle Isle, and Quebec. The German newspapers announce that this cable will be laid by a company already organized; but although this is probably an error, yet there seems no doubt but that such a cable will be a profitable investment from a business point of view, and will be of the highest importance in the prediction of storms, not only for the use of Europe, but especially for the use of navigators about to sail westward from those ports. (*D. M. Z.*, I, p. 410.)

96. The British Meteorological Office has entered into an arrangement with the Signal Office by which telegraphic warning is sent to British ports of the existence of any storm in the middle of the North Atlantic into which English vessels are likely to enter unawares.

97. R. Abercromby, W. Marriott, Lieut. H. H. C. Dunwoody, and Prof. H. H. Hildebrandsson, of Stockholm, have all recently published collections of popular sayings in reference to the weather. The latter especially expresses the following conclusions: (1) Any relation between the weather and the days of the week, or holidays, or the positions of the heavenly bodies, or the phases of the moon is absurd; (2) any prediction of the temperature of any year or month is impossible in the present state of our knowledge, and popular signs looking to such predictions are without value; (3) in general, it is desirable for vegetation and harvest that the seasons should have their normal temperature, rainfall, &c., and that is about what is attempted by all popular rules; (4) there are a number of rules for the prediction of the weather a short time in advance, some of which are quite safe. (*Z. O. G. M.*, XIX, p. 311.)

98. R. Abercromby presents a summary of prevailing weather types for use in predictions in Western Europe. (*Nature*, XXVIII, p. 330.)

99. E. Gelcich communicates the rules promulgated by P. Jauva, director of the Observatory at Manila, for the prediction of hurricanes. During the years 1877 to 1880 Jauva has successfully predicted forty storms. The following are his rules for Manila:

1. If the barometer at the time of the afternoon minimum, namely, between 3.15 and 3.30, falls to 755^{mm}, or if it exceeds 757 at the time of the morning maximum, namely, from 9.10 to 9.20, then one can definitely conclude that a cyclone prevails within a few hundred miles.

2. If at the time when the barometer should rise, namely, from 4 to 9 A. M., or from 4 to 9 P. M., it is observed to fall, then the cyclone is mov-

ing towards the observer's station, and he may expect its greatest severity.

3. If the barometer is stationary the cyclone is moving towards the observer, but its greatest severity will not reach him.

4. Ordinarily we observe high cirrus clouds when the cyclone is still 600 miles distant; these stretch out towards a definite point in the horizon and form cirrus strata that converge towards this point. If, now, we observe at equal intervals of time the direction of the vanishing point of the cirri and the height of the barometer, we may avail ourselves of the following rules: If the vanishing point is in the second quadrant and quite stationary, the cyclone is moving towards the observer, and we can estimate the probable severity of the storm by attending to the barometer in connection with the above three rules. If the vanishing point changes its position, the observer is outside of the trajectory of the storm; if it moves towards the south and east or towards the northeast and north, then the storm will pass by the observer on the south or the north side, respectively. (*Z. O. G. M.*, XVIII, p. 230.)

100. Mr. Herve Mangon, of Paris, president of the committee of the French Central Meteorological Bureau, reports that 83 per cent. of the predictions published by that bureau have been acknowledged good, and that of the storm warnings 51 per cent. were wholly verified, 33 partly verified, and 21 failed. (*Nature*, XXVII, p. 539.)

101. Dr. J. Lugli has compared the weather predictions made at the Central Office at Rome with the resulting weather very much after the manner adopted by the Signal Office, and gives the following percentages of verification for the three years 1880, 1881, 1882: For cloudiness, 84 per cent.; the condition of the sea, 78 per cent.; direction and force of the wind, 74 per cent.; thunder-storms, 66 per cent.; temperature, 68 per cent.; general weather, 72 per cent.; storm signals, 74 per cent. (*Z. O. G. M.*, XIX, p. 463.)

102. Dr. B. Overzier, of Cologne, having undertaken to publish weather predictions for each day one month in advance, these have been examined and verified by Dr. Assmann, by comparison with actual experience. In general, Dr. Assmann allows him 18 per cent. of verifications as to the velocity of the wind, 40 per cent. for cloudiness, 26 per cent. for rain, 24 per cent. for temperature, and 23 for thunder-storms.

103. [It would seem that Germany is troubled like America, where Vennor and Wiggins have for a long time vexed the public. The real remedy evidently consists in a better education of the public. When every person comes to understand that weather predictions do not depend upon astronomical configurations, but upon the solution of complicated problems, in which the topography and rotation of the earth, the moisture in the air, and the solar heat are the principal factors, they will, it is to be hoped, have learned to distinguish between the true meteorologists and the ordinary weather prophet of the almanac, even

as they have already learned to distinguish between the educated professional physician and the uneducated quack.] (*Z. O. G. M.*, XVIII, p. 383.)

104. Dr. A. Winkelmann states that in his previous work he showed the results of verifying rain predictions by considering only how many stations within the prescribed region for which the predictions were made had rain at the appointed time. From this he showed how, with the help of the knowledge thus obtained, we can so define the boundaries of the regions for which predictions are made that the separate stations in each group should have the greatest uniformity of weather. He showed that a verification of or agreement as to rainfall occurred at 85 per cent. of the stations, and that if all were divided into two groups the most advantageous arrangement could possibly only give 87 per cent. In this work Winkelmann had considered only the occurrence of rain without considering its quantity. He now offers a short study on the agreement of stations in any region as to the quantity of rain, or what per cent. of the total annual precipitation falls on those days for which these stations show a behavior different from that at the majority of stations. To this purpose he selects thirteen stations in Würtemberg, and first shows that for any station on 85.5 per cent. of days its weather agrees with that of the majority of stations. He then shows that the total rain that falls on the remaining 14.5 per cent. of the days amounts only to 5.49 per cent. of the total rainfall of the year; and, again, that on a rainy day at any station, which is also a rainy day for a majority of the stations, there falls 4.81 times as much rain as on a day when its rainfall is not accompanied by rain at other stations. He finally urges the importance of hourly or self registers, one of which he has constructed. (*D. M. Z.*, I, p. 387.)

105. W. Köppen, at the first regular meeting of the German Meteorological Association, Hamburg, November 18, 1883, gave a short account of his new method of verifying weather predictions. In the same manner as we examine the connection between different phenomena of nature, so can we investigate the connection between predicted and actual weather. Thus, if we count how often after a given prediction the weather has any one of the several given characters, then must this classification show whether there really was any scientific base for the prediction; if there was no such basis the numbers indicating the actual weather would show an entire independence of the prediction if a sufficient number of cases be examined. His examples show that the temperature predictions from day to day were sufficiently verified to justify the belief in a rational system of predictions, but the predictions from month to month afford no such conclusion. (*D. M. Z.*, I, pp. 39, 40.)

106. The Deutsche Seewarte states that our present methods of verifying weather predictions, which had their origin in America [namely at the Signal Office in 1871], and which have been used in Germany since 1877, consist in this, that the individual predictions are analyzed into

their elements, the latter compared with the resulting facts arranged in a series of from three to five categories, according to the proportion of their verification, and from these the percentage of verified and not verified is computed. The verification has, therefore, the character of a judgment or opinion; the arbitrariness that occurs in the grouping of the separate values can be very much limited by the exact prescription of the terms allowed to be used in the predictions, but it remains very difficult to remove all option, and the effort greatly increases the difficulty of making the verification. Still more difficult is it to make verifications for different regions of prediction, in order to obtain comparable figures that will give bases for estimating the success of the predictions within these districts, the value of the so-called local influences [and the relative ability of different persons who make predictions]. Especially has the present method the great objection that no account is taken of the doctrine of chances, and it is chance especially that must be taken into consideration in estimating the success or failure of a weather prediction; it is evident that this accidental chance of success is, however, not 50 per cent., as some are occasionally liable to assume, but the percentage due to chance must lie within very wide limits, according to the frequency of the occurrence of any meteorological phenomena; for example, predictions of thunder-storms which are verified to less than 30 per cent. can be very good, while predictions of wind force, whose verification can exceed 80 per cent., may be worse than if they had been based only upon the well-known general character of the weather of the season. For instance, Köppen's table shows that if we had for the whole summer uniformly predicted light and moderate winds, we would have attained nearly 100 per cent and have avoided three mistakes out of the five predictions of fresh or strong winds; on the other hand, out of 32 predicted thunder-storms 10, or 31 per cent., occurred, and 22, or 69 per cent., failed, but had we made predictions by chance we should have attained 22 per cent. of verifications. There is, therefore, need of some method which will give assurance whether and how far this class of predictions is based upon a real foundation. A method has been proposed by Dr. Köppen and has been tested by application to predictions for June, July, and August, 1884. In this method of verifying, the predictions for the northwest division of Germany as published in the daily bulletin are compared directly with the observations at the Hamburg Seewarte. The temperature observations are divided into three classes, according as they are more than 2° below or above, or in agreement with the normal for the month (or possibly the day). The temperature changes in twenty-four hours are divided into three classes, according as the thermometers have fallen or risen more than 1° or remained invariable. Cloudiness is classified as clear, cloudy, and overcast; strength of wind is classified as feeble or moderate, fresh or heavy, stormy. The wind direction and weather are similarly divided. The verifications are summed up in tables which show that the predictions are based upon

correct knowledge, since pure chance would otherwise give the same number of verifications and failures in each of the classes. (*D. M. Z.*, I, p. 397.)

107. [We are not able to see any radical difference between the exact method here proposed by Dr. Köppen and the actual experience of the Signal Office since 1873, at which time the expressions allowed to be used in prediction and the method of verifying began to be reduced to rules which have remained in force, except a slight steady change toward greater severity. We do not understand that by choosing Hamburg as an example by which to verify predictions for Northwest Germany, he means to imply that in a perfect system one should not take a number of other stations in Northwest Germany, going through a similar process of verifications for each one and take the average of the whole as representing the general percentage of verification for the whole district; this latter is essentially the process used for each of the districts recognized by the Signal Office. These districts were attempted to be so limited geographically that the average chance of verification at any one station (85 per cent.) should be equal to the average uniformity of geographical distribution of any one feature of the weather over that district, which latter was also estimated at about 85 per cent., and although these limits were fixed in 1871 they have not needed material change. The criterion just mentioned is evidently that which will give us the greatest economy in the use of words to predict the weather for the whole of a large territory like the United States. It was considered incumbent upon the predictor to distinctly predict for twenty-four hours in advance in regard to the weather, wind-direction, temperature, and pressure changes for every portion of the country, and yet but rarely more than twenty minutes of time was available for this prediction owing to the late hour (11 P. M.) when the observations were made and the imperatve necessity of finishing the predictions by 1 A. M. The necessity for the utmost economy of time and words thus led to the use of districts and their limitations in accordance with the above principle.]

III.—(*a*) AERONAUTICS; (*b*) THERMOMETERS AND DEW-POINT; (*c*) BAROMETERS; (*d*) ANEMOMETERS; (*e*) RAIN-GAUGES; (*f*) MISCELLANEOUS APPARATUS; (*g*) METHODS OF REDUCTION.

108. The Godard captive balloon seems to be a commercial success, as we see that it has lately been set up in connection with the International Exhibition at Turin, where short ascents are made, as at Paris and London. Father Denza proposes to have meteorological observations taken from the balloon. (*Nature*, XXX, p. 181.)

109. [The Army Signal Office has arranged for a number of ascensions for meteorological observations.]

110. J. W. Clark, in reference to the condensation of liquid films on wet solids, a matter that is of vital importance in the use of the dew-point apparatus, submits some notes and experiments which will afford

good starting points for those at work on the theory of this apparatus. (*Nature*, XXVII, p. 370.)

111. [Almost the only way to get a physically clean surface of glass is by heating it in concentrated sulphuric acid, to which a little nitric acid has been added, and then heating, after washing with pure water to remove the acid; such a glass surface exposed to the air for a short time is generally imperfectly wetted by water. The hygroscopic properties of physically clean surfaces probably need full elucidation before the dew-point apparatus can become a perfectly accurate physical apparatus.]

112. H. Kapeller has modified the construction of his combined maximum and minimum thermometer so as to secure the greatest simplicity and still accomplish a transportable, safe, and economical instrument. (*Z. O. G. M.*, XVIII, p. 225.)

113. Dr. R. Lenz described a method of utilizing the telephone for the measurement of temperatures at distant points which is applicable up to distances of 25 kilometers. (*Nature*, XXX, p. 346.)

114. Prof. William Förster describes some results of investigations into accuracy of thermometers carried out by the German Normal Standards Commission. Passing from the errors of the mercurial thermometer he considered the air thermometer, and showed that the chemical composition of the glass bulb affects even that, as experiments showed that all gases are more or less absorbed by the glass, and the more so the longer the gas remains in contact with the inner wall of the bulb, thus affecting the result among the hundredths of a degree. (*Nature*, XXX, p. 652.)

115. Prof. R. Weber has made a most laborious examination of the influence of the chemical constituents of the glass upon the depression of the freezing point of thermometers; he finds the best results with a pure potash alkaline glass free from soda, and it is probable that he will be able to construct a special glass in which the troublesome source of error is reduced to a minimum. (*D. M. Z.*, I, p. 286.)

116. O. Pettersson, of Stockholm, proposes improved methods for measurement of heat, namely, that the measurements should be made at a constant temperature and that the ice calorimeter of Bunsen should be improved by directly transforming the heat into work. In order to maintain a constant temperature he had recourse to a thermometric combination which proved unsatisfactory and substituted a method of measuring the work done by isothermic expansion of air. In this way he is able to measure the mechanical effect of radiations the caloric energy of which was only 0.08 gramme-calorie per minute. (*Nature*, XXX, p. 321.)

117. Mr. G. M. Whipple, of Kew, communicates preliminary results as to the discrepancies between various black bulbs *in vacuo;* he finds that among other things the effect of successively increasing the thickness of the coat of lamp-black is to raise the temperature, and that the

size of the thermometer bulb and of the inclosure is also important. [The complete theory of the Arago-Davy conjugate thermometers or actinometer has been worked out by Professor Ferrel and is fully given in his recent memoir on "Temperature of the Earth's Surface."] (*Nature*, XXIX, p. 208.)

118. J. T. Bottomly communicated to the Montreal meeting of the British Association for the Advancement of Science, the preliminary results of a course of experiments on the loss of heat by radiation and convection for bodies of different dimensions. His experiments are made on wires of different sizes both covered and bare, both in ordinary air and very rarefied air, the wire being heated by an electric current; he finds that, other things being the same, the smaller the wire the greater the emissivity; for a diminution of air pressure the emissivity decreases slowly down to one-half or one-third of the ordinary air pressure, after which it becomes very great as the vacuum becomes more complete. (*Nature*, XXX, p. 523.)

119. Dr. Maurer, of Zurich, contributes a study on the application of air thermometers to meteorological observations. He employed a thin polished cylindrical copper vessel 5^{cm} in diameter and 44^{cm} long, and also a thin brass cylinder 10^{cm} radius; in each receptacle was hermetically sealed a normal mercurial thermometer and the copper vessel then filled with pure dry air. This was then established in a double-louvre thermometer shelter of sheet zinc in which were also two mercurial thermometers, the whole being constructed entirely in accordance with the results of Professor Wild's investigations into the proper method of thermometer exposure for thedetermination of the temperature of the air.

The two free thermometers at a distance of 25^{cm} from each other agreed always within one or two tenths of a degree, but with regard to the thermometers within the metallic receptacle the following may be noted: If the temperature variations are slight and always slowly, steadily, rising or falling, then the inclosed thermometers follow these changes quite rapidly; if the temperature changes are rapid and large, followed by a constant temperature, the receptacles also follow closely; but if the changes are rapid in opposite directions, as happens in thunderstorms, partly cloudy weather, or alternating calms and winds, then there is no agreement whatever between the free and the inclosed thermometers, differences of one or more degrees being quite common. He therefore concludes that all records with such self-registering air thermometers must be accepted with great caution, as they frequently give results that have no scientific value. From a theoretical point of view it can be easily shown, as he has done, that the conduction of heat alone will bring the thermometers to equilibrium in about four minutes if inclosed within a brass sphere as above and exposed to a sudden change of air temperature of one degree. (*Z. O. G. M.*, XVIII, p. 334.)

120. Dr. C. Lang, of Munich, describes the simple method of deter-

mining the temperature of lakes, springs, and rivers at slight depths as adopted at the Bavarian stations. [As similar observations are made at all the Signal Service stations, and are desirable for all parts of the world, it is well to establish uniform rules and methods.] In Bavaria, as in the United States, a small metallic vessel is lowered to the desired depth, filled with water, and brought to the surface. The thermometer being always in place within the vessel, the reading should be made as soon as possible after pulling the apparatus up. Among the precautions to be observed, the most important is the necessity for allowing the whole apparatus to remain in the water at the proper depth for a sufficiently long time before the observation is to be made. Since the water penetrates into all parts of the apparatus as it is lowered into position, we shall obtain only an average indefinite temperature datum unless the whole is left at the proper depth until the water and the metal attain the proper temperature; in fact, it is best to leave the apparatus in the water for the whole time intervening between two observations. With the apparatus used in Bavaria Dr. Lang finds that two or three minutes, at least, are required before the thermometer within the case experiences any change of temperature, after being taken out of the water. (*Z. O. G. M.*, XVIII, p. 367.)

121. A. Angot, of Paris, publishes in the annals of the Central Meteorological Bureau a new determination of the constant of the psychrometer formula, based on 3,670 comparisons with dew-point apparatus, and made partly at Paris, and partly on the summit of the Puy-de-Dome. He finds that the value of A varies with the difference $t-t'$, and constructs tables accordingly.

122. [The results of Angot's work seem still to require revision in order to adapt the formula to the extreme conditions which are found in the United States. It has, therefore, been found necessary to pursue an extensive further system of observations at Washington, Pike's Peak, and Yuma, the results of which will be eventually deduced by Professor Ferrel, of the Signal Office, who has already completed a thorough analytical study of the theory of the psychrometer. It is, however, evident that the various forms of dew-point apparatus have also peculiar systematic errors, and our next attention must be given to these.]

123. A. Sprung suggests a new method for determining the dew-point. He says, correctly, that it is difficult to determine the exact moment when condensation begins in the ordinary use of the Regnault apparatus, and especially when the temperature is below freezing. He suggests that it would be much more convenient and safe to observe the moment of condensation when the cooling of the air takes place, not in a thin layer, but through its whole mass, so that the condensed vapor shall appear as fog. He proposes to produce this condensation by a rapid change of volume, using a small air-pump, connecting with it a cylindrical receiver whose ends are closed with brass plates; the

piston of the pump to have its motion limited by a motionless screw so that the exact amount of its motion and consequently of the expansion and cooling of the air can easily be determined.

124. [Espy's nepheloscope seems to have realized Sprung's idea. Many observations with it are given in Espy's works.] (*Z. O. G. M.*, XVIII, p. 403.)

125. Professor Crova, in the Meteorological Bulletin of the department of Hérnault, gives some examples of the use of his new form of dew point apparatus known as the hygrometer with interior condensation. The advantage of this method consists in this, that the precipitation is not influenced by the currents of air, which by their strength and variability interfere with Regnault's apparatus. Even with the greatest dryness of the air Crova's apparatus gives good results when Regnault's refuses to work. In the illustrative observations given by Crova we find, as was to be expected, that Regnault's apparatus gives dew-points too low by as much as 1°.6 C. (*Z. O. G. M.*, XIX, p. 45.)

126. R. H. Scott has published the results of observations made in different forms of thermometer shelters and at different altitudes for the purpose of determining the influence of these circumstances upon the recorded temperature and moisture of the air.

127. [As a means of deciding on the relative merits of various methods of exposure of thermometers this important series of observations lacks one essential, namely, simultaneous observations of the true temperature of the air of each locality taken by some method whose theory can be accurately investigated; this essential has lately been supplied by Ferrel's studies into the theory of the ordinary thermometer, the whirling psychrometer, and other apparatus.]

128. Taking these records as they stand, Hann shows that the daily range of temperature diminishes with the height above ground by an amount equal to 1°.3 C., in the annual means for exposures, respectively, 10 and 129 feet above the earth. The lower exposures invariably show a higher vapor tension and dew-point than the upper, but the relative humidity has no such regularity. Classifying the observations according to the conditions of the sky, as being either perfectly clear or perfectly cloudy, rainy or foggy, he finds that at all times of day, winter and summer, during fog the temperature increases with the altitude. The differences between temperatures at high and low stations are smallest during rain. During clear weather, in the evening, the temperature increases with the altitude, but at mid-day it diminishes rapidly; at 9 A. M., in clear weather, in winter, it is warmer above than below. (*Z. O. G. M.*, XVIII, p. 395.)

129. Dr. R. Assmann in some remarks upon the sling-psychrometer, states that an observation of the temperature of air perfectly free from objectionable features is a matter of the greatest rarity in meteorology; so difficult is it to attain a thoroughly satisfactory exposure. Until recently (and even now in many Prussian, English, American, and other

stations) the thermometer is hung in the open air against the wall of some house, entirely unprotected from rain and radiation and without any uniform altitude above the earth's surface. Even the most careful observations (made in the large thermometer shelter of the Magdeburg observatory, constructed according to all the rules of the art according to Wild's plans) show that many errors are still apparent which interfere with the general reliability of this method. During the rapid changes at sunrise and sunset the thermometer in the Wild shelter is very much behind the true temperature, especially in calm weather. The wooden louvre work and the quiescent air within require an appreciable time to change their temperature; moreover, we do not wish the temperature of a mass of air thus inclosed, but that of the free air as affected by radiation. It is necessary that the thermometer should give the temperature of the air with the greatest accuracy, and yet follow the temperature changes with great rapidity; it must be protected from radiation and rain. The temperatue must be independent of incidental local surroundings, the method must be available with the cheapest possible apparatus, and he concludes that the sling-thermometer, hitherto but little used in Germany, is the best and most appropriate for general use. It is to a high degree sensitive, the injurious influence of calms is overcome by its rapid movements through the air; the radiation has almost no influence upon it; even in the full sunlight it can be easily protected from rain; the observer can choose a shady place, and the apparatus is the cheapest imaginable. Still more is all this true of the psychrometer, which as it is now generally used is acknowledged to be the most uncertain instrument in meteorology. It is easy for the observer to give the sling-psychrometer such a linear velocity that it will be brought down to the proper temperature in a few seconds; some experiments by Assmann show that it required only one-ninth of the time given to a stationary psychrometer, the velocity used by him being 6 meters per second. The form of sling-psychrometer recommended by Assmann is manufactured by Fuess of Berlin; it consists of two delicate mercurial thermometers divided to one-half degrees; these are mounted upon a fork-shaped wooden stand through which a silk thread is drawn. The price complete is 13 marks. (*Z. O. G. M.*, XIX, p. 154.)

130. [The sling-psychrometer, in a well-contrived shape, was issued by the late Dr. T. Craig, of the Surgeon-General's Office, in 1868, to all the observers at Army posts, where it is probably now in occasional use. Numerous experiments with various forms of this instrument have been made by Prof. H. A. Hazen at the Army Signal Office during the past few years, and it is evident that either it or the whirled thermometer or the ventilation psychrometer are the only ones that can be recommended for accurate observations, as it is thoroughly essential that a nearly uniform rapid current of air should flow past the thermometer.]

131. Prof. H. Wild makes a lengthy reply to Dr. Assmann's communication and gives in full his own views as to the present condition of our

knowledge of the methods of determining the temperature and moisture of the air. He lays it down as a criterion by which to judge of the excellence of any thermometer shelter, that if we place within the shelter a ventilating apparatus and read the thermometers both with and without ventilation then the exposure is satisfactory if on the average no greater difference occurs than $\pm 0^{\circ}.1$ C. He then states that the experiments demonstrate that the motion of the thermometer through the air as in the rotation and the sling thermometers or the movement of the air past the thermometer, as in the Italian ventilated thermometer, is a much less effectual method of overcoming the effects of radiation than is the simple protection of the thermometer in a properly constructed shelter such as his own. [The actual effect of each has been pretty thoroughly studied by Ferrel and Hazen.] He recommends urgently the avoidance of large wooden shelters or other masses of wood, as they must retard the temperature changes.

132. [In 1865–'66 the present writer, while residing at Poulkova Observatory and studying atmospheric refraction, constructed a thermometer screen of oiled paper, which is possibly still there, and placed within it bright and black bulb thermometers side by side, adopting as the criterion of excellence of the screen that it must be a perfect protection from outside radiations if these two thermometers read alike, which they in fact generally did. The theory of this method and the formula for correcting the bright bulb in case of any small difference have been lately given by Ferrel in his memoir on temperature. A quite thorough investigation of the merits of various thermometer shelters and the relative effect of solar, terrestrial, and instrumental radiation and of convection by wind has been recently made by H. A. Hazen, from which it would appear that the Wild shelter (a wooden lattice-work inclosing a sheet-zinc screen with the thermometers inside) does not quite give sufficient ventilation for warm climates; in fact, the meteorologist needs the temperature and moisture of the free air, and the criterion of a good shelter must be that the thermometer within gives the same temperature as the thermometer outside, after correcting the latter for solar and other radiations, the formulæ for which have also been given by Ferrel.] In reference to determining the moisture of the air Wild relies largely upon the studies of Sworykin, who found that with a wind of definite and sufficiently high velocity the psychrometer, with ventilation, gives very accurate results as compared with Alluard's dew-point apparatus and Schwackhöfer's volume hygrometer. He recognizes the value of the rotation-psychrometer and the sling-psychrometer, but thinks on account of the time required these methods should only be employed at special stations, and that for ordinary use it is only necessary to add to his own shelter a ventilating apparatus fastened to the floor of the shelter, and which is rotated by the hand rapidly just before making an observation; this draws the air from below up into the shelter and gives the necessary ventilation for both dry and wet thermometers. (*Z. O. G. M.*, XIX, p. 433.)

133. [The dependence of the psychrometer constant upon the velocity of the wind, and the effect of barometric pressure, especially at such high altitudes as Pike's Peak, are matters that are now being investigated by the Signal Office, and it is to be hoped that formulæ and tables which may be approved by the International Congress of meteorologists will soon be available. But still more desirable is it that some improved dew-point, chemical or other method may be invented practicable for daily use by all observers, and calculated to replace the psychrometer.]

134. R. Fuess, of Berlin, describes the Assmann anemograph and the Sprung-Fuess anemograph, both as made by himself in a high style of elegance and perfection. The latter apparatus cost 1,100 marks, and is more complicated than that of the former, whose price is 630 marks, but the Sprung-Fuess overcomes several difficulties, and is probably more desirable. Both are in working order at several stations. (*D. M. Z.*, p. 356.)

135. Professor Börnstein, of Berlin, has constructed a pressure anemometer, consisting essentially of a ball 126^{mm} in diameter at the top of a heavy vertical rod, which at some distance below is supported by a gimbal or universal joint; from the lower end of the rod hangs a wire by means of which record is made of the deflection of the rod from the vertical. (*Nature*, XXIX, p. 280.)

136. Dr. Maurer, of Zurich, has established at the station on the very summit of the Säntis a self-recording anemometer specially made by Munro, of London, for this station. He gives a description of the apparatus and the lightning protection which may be of value to those establishing mountain stations elsewhere. With reference to self-recording thermometers he states that the experiments of Prof. A. Fischer showed uniformly that metallic spirals, &c., always lag behind the true temperature of the land. The same result has been deduced by Hann in comparing a Hottinger metal thermograph with a Theorell self-registering mercurial. Maurer has therefore introduced the so-called upset thermometer invented by Negretti and Zambra. (*Z. O. G. M.*, XVIII, p. 411.)

137. [The comparison between the normal or standard barometers used in the various national observatories and weather services has progressed but slowly through the past year. Owing to the sickness of Professor Waldo the extensive and important work undertaken by him at St. Petersburg, Berlin, Hamburg, Paris, London, and Washington has not as yet been discussed and made available.]

138. Denza has published the results of the barometric comparisons made by Tacchini and Chistoni, from which we quote the following:

The normal barometers at St. Petersburg, Paris (College de France), Kew, and Moncalieri agree with each other to within 0.05^{mm}. The barometers at Greenwich, Geneva, Stockholm, Vienna, and Algiers are less than 0.05^{mm} higher than the St. Petersburg normal. The barome-

ters at Hamburg, Copenhagen, and Munich are about 0.2^{mm}. higher than the St. Petersburg standard. (*Z. O. G. M.*, XVIII, p. 359.)

139. N. von Klobukoff describes the method of Bogen for filling barometer tubes and explains his own improvement thereupon. It consists, essentially, in attaching to the main tube another glass tube of about equal length by a short flexible-rubber tube. Mercury is poured in through the latter, and by a proper manipulation the first is filled, with but little chance of leaving any air bubbles. The method is applicable to barometer tubes of all kinds. Sprung remarks that by warming the mercury the filling is materially assisted. Whipple, of Kew, considers the Bogen method (unless the temperature is elevated somewhat) inferior to that of Captain George, who sweeps the bubbles of air out of the tube by means of a feather. The method of Bogen is used to a considerable extent at the Hamburg Seewarte. (*D. M. Z.*, I, p. 289.)

140. Professor Mendeleef, of St. Petersburg, has during the past few years made a large number of improvements in apparatus for measuring the density of the air, as also in barometers, and has done much to determine the law of density of the air at various temperatures and pressures; he has among other things shown that as the rarefaction of gases goes on a maximum volume or limit is reached, like the minimum or limit for compression, so that the gas when rarefied does not merge into the luminous ether, but becomes, so to speak, like a solid body, so that the atmosphere of the earth has a limit. (*Nature*, XXVII, p. 568.)

141. H. Dufour and H. Amstein have described a new form of self-registering barometer, based upon a new principle, and which is distinguished above all others by the simplicity and ease of its construction, as well as by the accuracy and sensitiveness of its records. The principle consists in this, that the changes in atmospheric pressure shall alter the position of the center of gravity of a free column of mercury, and that these changes shall be recorded in the simplest possible manner. The barometer tube is bent at right angles to itself and is fastened to a horizontal axis perpendicular to the plane of the bent tube, consequently the rise and fall of mercury in this tube alters its center of gravity and its position of equilibrium. A pointer is attached to the axis, and, turning with it, gives a magnified record of the changes of pressure. The authors call this form of apparatus the "Hebel" or lever barometer. They develop the theory of the barometer and the methods of installing and correcting it, and give numerous observations. (*Z. O. G. M.*, XVII, p. 294.)

142. W. Köppen, in some remarks upon the use of the barometer as a means of measuring gravity, compares together the suggestions of von Wüllerstorf-Urbair, Zöppritz, Siemens, Mascart, and others, and shows how little likelihood there is of deducing from this anything of value in comparison with the pendulum observations of the geodesist. He takes occasion to state that it is much more proper to correct the readings of the mercurial barometer so as to reduce to a standard gravity of 45° than to neglect this and apply the reverse correction of the aneroid barom-

eter, for it is certainly more scientific and important that we should in this way obtain a correct measure of the gradient force that produces the movements of the atmosphere, and it is much to be desired that this reduction should be applied generally to individual observations rather than to monthly and annual averages. As the Signal Service has announced the adoption (on and after January 1, 1885) of this correction in its publications, he hopes that the co-operation of other meteorologists may be prompt and general. (*D. M. Z.*, I, p. 323.)

143. Prof. R. Börnstein, of Berlin, has discussed the value of the ingenious suggestion made by Professor Nipher, of Saint Louis, that a protection in the form of a funnel be given to a rain-gauge in order that the influence of eddies of wind around the mouth of the gauge may be diminished. After recounting some of the theories explanatory of the diminution in the catch of rainfall, all of which have been reduced to one, namely, the greater formation of eddies by the stronger winds at high exposures, he states that Nipher's proposition seeming perfectly rational it was tested by experiments by himself. Two similar rain-guages, having receiving surfaces of 500 square centimeters, such as are used at the stations of the Deutsche Seewarte, were established near each other, one protected, the other unprotected; both were on the roof of the Berlin Agricultural High School, near the southwest corner, and 26^{m} above the ground. The position of the gauges was changed several times within narrow limits on the roof. The greatest individual difference between the catches of the two gauges was during a light rain in January, and amounting to over 500 per cent., the protected gauge giving the larger figure. The annual average difference was about 11.5 per cent. There is therefore no doubt as to the general value of Nipher's invention; but this becomes still more remarkable if we classify the precipitation, whence we find the ratios or the catch of the unsheltered divided by that of the sheltered gauge. The figures are as follows: For snow, the ratio is 0.54; for fine rain, 0.66; for rain and snow, 0.82; for rain with hail, 0.89; for rain, 0.90; for heavy rain, 0.96; whence it seems that Nipher's device gives the rain-gauge a better protection, and that it therefore makes better measurements in proportion as the wind can more easily deflect the precipitation; and in general his device does better in proportion as the wind is stronger. Perhaps the most important defect in the Nipher gauge is that with heavy snowfall the protecting funnel is soon filled up, and then ceases to work. (*D. M. Z.*, I, p. 381).

144. Dr. C. Lang, of Munich, has experimentally investigated the quantity of rainfall as dependent on the shape of the rain-gauge, an investigation which, as he says, is the more important now that we are establishing such a great additional number of rainfall stations and are about to discuss the climatic conditions of various portions of limited regions, where the natural differences will be slight and comparable with the errors of observation. In general we do not in meteorology expect absolutely correct measures of any element, but are satisfied if uniformity

is attained, even if slight constant errors remain; but in rainfall measures even uniformity has never yet been obtained. Thus the new reorganization of the official stations in Bavaria in 1878 has been productive of an abrupt change in the rainfall records, due to improved instruments and exposures, by virtue of which some stations record twice as much rain and others only two-thirds as much as they formerly did. It is correctly concluded on the basis of several investigations (Bache, Symons, Jevons, &c.) that the greater part of this irregularity is due to the wind and its influence either on local distribution or on the instrument and its exposure. To obviate this latter, rain-gauges have been established in pits or hollows, so that their apertures are protected from severe wind, but none of these are appropriate for the measurement of snow, which is easily whirled out of the gauge unless the latter is furnished with a conical rim; but in any case, however, the measurement of the snow is not of so great importance, because it hardly forms one-eighth of the rainfall. [This latter, which is true for most civilized countries, is, of course, not quite true for some regions in which meteorology has an especial interest, namely, the extreme north and south temperate and polar regions and those in which glaciers have a tendency to form.] Lang's views as to the proper form of a rain and snow gauge were originally about as follows: A conical addition as a cap to the gauge will give the wind that blows along its surface an upward tendency, depending upon the strength of the wind, the size and inclination of the conical surface; the air thus forced up will carry with it a definite zone of particles, which will depend upon the strength of the wind and the size of the surface. Since now, for gauges whose mouths have different sizes and are furnished with the conical caps, the sloping surface of the latter increases as the diameter, but the catching surface as the square of the diameter, it is evident that by reason of this conical cap the ascending air currents will be of more importance in proportion to the ratio between the surface of the cone and the mouth, that is to say, in proportion as the gauge is of smaller dimensions, for the current carries away from the mouth the suspended drops of rain or flakes of snow. This source of error is unavoidable, but by a proper selection of ratios can be made very small. Lang has, therefore, chosen the following four forms for experimental comparisons:

1. Of the same form as that used at the Bavarian stations since 1878, namely, a cylinder about 40 centimeters diameter, surmounted by a cone whose vertical angle is about 60°, and so truncated that the aperture or mouth of the gauge has a diameter 25.2 centimeters, or an area of $\frac{1}{20}$ of a square meter.

2. A similar gauge whose cylinder has about 20 centimeters diameter, and whose cap has an aperture of 16 centimeters, or $\frac{1}{50}$ of a square meter.

3. A gauge similar to No. 1 and cylinder of the same size, but with a conical cap so truncated that the mouth has a diameter 16 centimeters, namely, the same size as the mouth of No. 2.

4. A simple cylindrical gauge 25.2 aperture, or $\frac{1}{20}$ square meter, which, of course, having no conical surface, should give results free from any error the latter may introduce.

This latter proved wholly unreliable in drifting snow; the comparison, therefore, between these as snow-gauges was given up for the present, but as regards rainfall during the summer months the following results are expressed in percentage of the catch given by No. 1, namely: No. 1, 100; No. 2, 97.5; No. 3, 95; No. 4, 99. The small catch of No. 3 may be due partly to the general poor results given by small apertures, but if previous hypotheses were correct must also be partly due to the increased ratio between the inclined conical surface and the aperture of the gauge. These two results, however, suggest that so far as the heavier rainfall of the year is concerned one need not be very anxious about the instruments, provided they are not too small; the more important question will be as to the proper exposure of the gauges and radical differences in the structure or shapes of the gauges. At Münich the gauges of the Central Meteorological Station, and that at the Observatory of Bogenhausen 2.7 kilometers apart, on the average of several years, with comparable instruments of this same pattern, show that 8.6 per cent. less precipitation fell on the right than on the left bank of the river Isar, while for a period of nine months of special comparative observations 16 per cent. less fell on the right than on the left side. Special observations are now being made in this region at three other stations, namely, on the roof of one of the public buildings of the city and on the grounds of two of the observatory buildings. The differences between the records are such that at least five stations would seem necessary if we would have a correct result as to the distribution of rain over a space of one English mile square, or at the rate of 3,500 stations for one division of Bavaria. We must conclude, then, that meteorology will profit least of all by the ordinary rainfall measurements, although for hydrography and engineering they are very important. (*D. M. Z.*, I, p. 431.)

145. G. J. Symons, in the British Rainfall for 1880, gives a collation of results as to the effect of elevation above the ground upon the quantity of rain caught by the rain-gauge. The following table shows the percentage of the upper gauge as compared with the amount caught by a gauge at the surface of the ground:

Station.	Altitude of the gauge.	Percentage.
	Feet.	
Boston	260	53
York	213	60
Derby	174	86
Chester	160	70
Westminster	151	54
Oxford	112	61
Dover	99	42
Dublin	90	66
Paris	89	88
Whitehaven	87	72
Sheerness	67	54

We see from this that in general the average of 64 per cent. will represent all these observations with equal accuracy, and that there is no sensible diminution in the quantity of rain from 67 up to 260 feet above the earth's surface. It is also well known that there is only a slight percentage of increase in the velocity of the wind as we go from 67 up to 260 feet, and the conclusion drawn from other observations is, therefore, corroborated by this present table, according to which the rapid diminution of rain caught by gauges whose altitudes are between zero and 60 feet is due almost wholly to the increase of the wind at the high altitudes. The large deviations from average results shown by different gauges, even at the same altitude, depend upon the shape of the rain-gauge and its location, and especially upon the configuration of those parts of the building that are near it. (*Z. O. G. M.*, XVII, p. 294.)

[The results given by Börnstein (§143) show that this injurious effect of altitude is almost wholly neutralized by Nipher's improvement.]

146. Capt. C. Rung, of Copenhagen, describes a form of self-registering rain-gauge which he calls the sine balance, wherein the weight of the water is balanced by a heavy lever arm; the water acts on a constant leverage, and the weight on a variable one the sine of whose angular variations is proportional to the weight, and is recorded upon an endless sheet of paper. The same principle applies to the record of evaporation, the growth of plants, &c. The cost of this ombrograph, as manufactured by Kemp & Lauritzen in Copenhagen, is about $75. (*D. M. Z.*, I, p. 461.)

147. Dr. Maurer describes a form of self-registering rain-gauge which preserves a continuous record of the rainfall and the time; it is manufactured by Hottinger, of Zurich, and has already been extensively introduced by Austrian, Roumanian, and other meteorological services. (*Z. O. G. M.*, XIX, p. 180.)

148. Dr. Assmann, of Magdeburg, has established a station upon the Brocken, where he has erected a self-recording rain-gauge, which apparently runs without trouble throughout the whole winter; the snow caught therein is melted by the heat from the chimney, and immediately flows to the measuring apparatus in the room below, thereby avoiding the great loss that occurs when strong winds blow. The rain-gauge is surrounded by a large shield of wire net work, as suggested by Nipher. The experiments have shown that snow at a temperature of —6° centigrade, on being thrown into the gauge, was within 6 seconds collected within the room below, as warm water at a temperature of 10°. An apparatus for the measurement of the quantity of frost formation that accumulates on every exposed surface is described as follows: Two iron rods, 1 meter high, have at their lower ends a wide-open flask, into which flows the water which may result from any melting due to the sun's heat. One of these rods and flasks is exposed at the moment when the other is taken in; when brought in all the frost upon the rod

is melted and added to that which had been caught in the flask. (*Z. O. G. M.*, XVIII, p. 68.)

149. Dr. W. Zenker states that after using for many years a method of determining the heights of clouds, which afterwards developed what is known as Braun's nephoskope, he then devised a method for photographing the clouds, which, however, he was not able to put in practice until 1882, and with his present experience he is able to describe an arrangement which he thinks will be thoroughly satisfactory, and which is about as follows: Two or three photographic cameras of the same focal length are needed, two of which are placed on the ends of a base line, their axes parallel to each other, directed toward the cloud, and simultaneously exposed and closed. His own apparatus has the focal length 0.5 meter, the objective being an achromatic telescope lens, the sensitive plate being set at the chemical focus for parallel rays. The plates are gelatine dry plates; the simultaneous opening and closing of the apparatus must be obtained by electric contact, so that only a momentary exposure will be made; a third camera, stationed alongside of these two and parallel to them, can be exposed ten seconds later. By this third photograph the movements and changes in the clouds can be determined. We can also obtain this third photograph by a second exposure of either one of the first two cameras, which method has the advantage of being independent of the adjustment of the two axes. The distance of the two cameras from each other may ordinarily be 100 meters. There are three methods of pointing the cameras, each of which has its advantages: (1) if they are pointed towards the zenith we have the best position for determining the height of the clouds, while the direction and velocity of movement are determined directly without computation; the direction of the four principal points of the compass can be photographed upon the plate by the shadows of wires placed immediately above it; (2) pointing the camera towards the sun: this has the great advantage that we can utilize the picture of the sun's disk to obtain the direction or the parallelism of two directions with greatest safety; measurement from the sun to the cloud gives us the parallax of the cloud to a minute of arc; (3) pointing the camera toward the horizon: this has the advantage that the clouds are photographed in vertical section, and, moreover, there is no danger that any cloud feature appearing in one photograph will be obscured in the other by intervening portions of the same or other clouds; but this advantage is balanced by the fact that the distance of the clouds in the horizon is always great, and the base line of 100 meters must be proportionately increased; an error in the direction of the axes of the cameras is therefore here of greater importance, and to counteract this it is important to photograph on the same plate some distant object (*e. g.*, a church spire), from which as a base the horizontal and vertical angular measurements can be made. Zenker states that we can thus follow in the cirrus clouds the sinking, step by step, of the upper warm and moist current of air; the rising of

the cumulus clouds by day and their sinking by night; the true form of the thunder clouds and their method of growth, and the locus within the cloud where the lightning is developed. (*D. M. Z.*, I, p. 4.)

150. [It seems strange that the numerous suggestions made in England, Germany, and America for many years past as to the use of photography for determining the height of clouds should as yet have been earnestly taken up by only one person, Mr. W. Abney, who, in September, 1883, began active work on this subject at Kew. A beginning in this direction was made in 1871 by the Signal Office, and we are now promised that good work will be done by the photographers of the U. S. Geological Survey.]

151. A. Richter proposes to determine the altitudes of clouds and their true velocity from observations made by two observers at quite a distance apart vertically instead of horizontally. This method is especially applicable to mountain regions and to those who have access to very tall towers. (*D. M. Z.*, I, p. 166.).

152. Various forms of sound radiometers were described by Dworak to the Berlin Physical Society in March, 1884. [Either by these or by means of Edison's phonautograph we may still hope to obtain some method of measurement of the intensity of thunder. The gradual dying away of thunder and of the rolling noise frequently likened to an explosion emanating from a bright meteor can give us some information as to the condition of the atmosphere at high regions.] (*Nature*, XXIX, p. 363.)

153. J. H. Gladstone, as a member of the Commission for Light-Houses and Marine Signals, has expressed the necessity and possibility of establishing some standard for the measurement of the density of fog. His observations show that only spots or streaks of country are covered at any one time with dense fog; that the fog is much more uniform over the sea than over the land, and that its geographical distribution is very irregular. Usually only a small portion of Great Britain is affected at any one time; the foggiest months are January and June; November is the foggy month for London, but not so for the rest of England. The foggiest portion of the coast is the southern point of the Hebrides, and fog especially occurs where the wind from the sea is turned upwards by striking hills and cliffs. Hitherto the observers have simply distinguished between mist, fog, and heavy fog. Gladstone urges that the record should be made more accurate, using Cunningham's proposition, namely: a staff placed at 100 yards distance in front of a painted red circle, and becoming invisible, requires the entry of the word "fog." Symons proposes a substitute, as follows: A series of 5 screens, each of black and white stripes, screen No. 5 having broad stripes, and No. 1 narrow ones. The fogs to be recorded as of intensity from 1 to 5 according to the visibility or invisibility of these screens. At night-time the screens are to be illuminated by a lamp from behind, all being

placed upon an axis and at a uniform distance of 20 yards from the observer. (*Z. O. G. M.*, xviii, p. 237.)

154. G. M. Whipple, of Kew, proposes to apply Sir Francis Galton's method of composite portraiture to the study of meteorological observations. Thus, by selecting a large number of typical storm-charts and superposing their prominent features upon one chart, we may finally obtain a tracing that may be considered as an average normal presentation of facts. [This idea of saving the labor of numerical compilations has been independently applied to the same study by W. M. Davis, of Cambridge, Mass., who has thus thrown upon one chart the results of a large number of observations bearing upon tornadoes.]

155. Prof. K. Weihrauch, of Dorpat, has studied the proper method of taking the arithmetical mean of a series of values of the relative humidity. The arithmetical mean is always proper when the quantity is directly measured and has no algebraic connection with other objects of observation; this is true of temperature, absolute humidity, pressure, &c. But the relative humidity is the ratio of two numbers, and the average value of these ratios is not the same as the ratio of the average values. The numerators and denominators of the fractions that constitute relative humidities have each regular diurnal periods, and the diurnal periodicity of the relative humidity is therefore a complicated function of the other two. The true average humidity for the day can only be found by knowing the true average temperature of the air and absolute humidity, and it will differ therefore from the simple average of a few observed relative humidities. In general Weihrauch finds that the true relative humidity is less than the arithmetical average, and the true amplitude greater than the arithmetical difference. He shows that it is necessary for us to give up taking the arithmetical mean relative humidity on account of systematic errors, which all lie in one direction. We must undertake a slightly greater labor, namely, the addition of the maximum vapor tension to each table of daily temperatures, with which data the true mean humidity can easily be calculated by the method which he gives. The hourly, daily, monthly, and yearly mean maximum vapor tension should also be computed for sake of the convenience with which we then compute the true average for long periods. (*Z. O. G. M.* xix, p. 265.)

156. [Prompted by the many troubles which beset the use of relative humidities, and on account of the decided direct advantage of using the dew-point in the prediction of frosts, rain, snow, fog, &c., the Signal Office has for some years introduced this latter datum into its statistical tables and daily weather maps. As the dew-point is a matter of direct observation, and has no necessary relation to temperature, its mean value can be taken without incurring the objections urged by Weihrauch against the relative humidity. If, however, we desire to compute the mean absolute or relative vapor tension from the monthly

average dew-point, we must add the maximum and minimum values for use in a method similar to that which he has pointed out.]

157. F. Erk, from a study of thirty-three years' self-registered temperatures at Munich and a discussion of the theories of Weilenmann and his predecessors, finds that the best combination of three daily observations of temperature is $\frac{1}{4}$ (7 A. M. + 2 P. M. + 2 × 9 P. M.), and that almost the same accuracy is attained by the following combination: $\frac{1}{4}$ (8 A. M. + 2 P. M. + 2 × 10 P. M.). If three observations must be combined into a simple arithmetical mean, then the best combinations are as follows: $\frac{1}{3}$ (6 A. M. + 2 P. M. + 10 P. M.) and $\frac{1}{3}$ (7 A. M. + 2 P. M. + 10 P. M.). Numerous other combinations are examined by Erk and their advantages discussed. (*Z. O. G. M.*, XIX, p. 254.)

158. Prof. K. Weihrauch states that the principal objection to the use of the four components of the wind—north, south, east, and west—as measured in some anemometers, in place of the total velocity and the direction, is said to be, that by it the mean velocity and direction and the velocity of individual directions as well as the mean value of wind force, irrespective of direction, cannot be given. He then proves that this objection is a mistake, at least so far as regards the arithmetical mean velocity, which can be found from the sum of the four components by simply multiplying it by the factor $\frac{\pi}{4}$. The denominator 4 is, however, rather small, and the figure 5 will apparently do better. (*D. M. Z.*, I, p. 291.)

159. Jamin, of Paris, proposes that meteorologists, instead of the relative humidity, shall introduce the quotient found by dividing the weight of the moisture by the weight of the dry air actually found in the same volume; that is to say, for $\frac{e}{E}$ substitute $\frac{e}{b-e}$. (*Z. O. G. M.*, XIX., p. 408.)

160. [This proposition seems not yet to have found very hearty accordance. Apparently Jamin desires by this substitution to obtain figures that will express both the quantity of moisture in the air and its relation to the quantity required for saturation. As he expresses it, the new ratio gives us the hygrometric constitution of the air, and shows the changes that are brought about by diurnal and annual variations at different altitudes and latitudes. It would seem that if the absolute quantity of moisture in the air is really desired it would be simpler to publish it directly in the shape of the weight or tension of the aqueous vapor alongside of the ordinary percentage of relative humidity, as is in fact frequently done. Simplest of all in our estimation is it to publish the temperature of the air and the temperature of the dew-point, leaving it to the climatologist to deduce such phenomena as most affect vegetation and animal life, and to the physical meteorologist to deduce such additional data as he may desire. The daily prediction of the dew-point is as practicable and desirable as that of temperature; it is to be hoped that the direct determination of the dew-point may soon be made practicable for all observers.]

IV.—(*a*) CONSTITUTION OF THE ATMOSPHERE; (*b*) GENERAL PHYSICAL PROPERTIES OF THE ATMOSPHERE, THE OCEAN, THE LAND.

161. E. Rogovski offers to the Journal of the Russian Chemical and Physical Society a mathematical and physical study on the structure of the atmosphere. He thinks that the ordinary formulæ can be used up to 10,000 meters, but above that the constitution varies with the height, the proportion of oxygen diminishing, and at the height of 1,000 kilometers the density is nearly zero. (*Nature*, XXX, p. 118.)

162. A. Lévy, of the observatory at Montsouris, has conducted a daily series of observations on the chemical constituents of the atmosphe , of which Prof. E. Wollny gives a brief summary:

1. Ozone.—The average weight in milligrams per 100 cubic meters is 1.9 for 1877; 1.5 for 1878; 0.8 for 1879; 0.6 for 1880. The quantity of ozone with southerly winds is very large; that with northwest to northeast winds, quite small.

2. Ammonia.—The average quantity of ammonia in milligrams per 100 cubic feet is as follows: 3.2 for 1877; 1.8 for 1878; 2.1 for 1879; 1.8 for 1880. The quantity of ammonia in the warmer half of the year is sensibly greater than in the colder half. It also varies very much in different localities near the observatory.

3. Organic nitrogenous substances.—The average quantity was 0.6 milligram per 100 cubic meters. The deviations therefrom were too small to recognize any material changes.

4. Carbonic acid gas.—The average for the whole period was 30.2 liters per 100 cubic meters. The variations in the quantity of carbonic acid are quite considerable, but probably no more than in similar measurements by other observers. (*Z. O. G. M.*, XVIII, p. 380.)

163. Müntz and Aubin have invented a very accurate method of determining the quantity of carbonic gas in the atmosphere, and have taken a series of determinations at the summit of the Pic du Midi, at a height of 2,877 meters. They find that the average at this altitude is 2.86 parts in 10,000 by volume, and at intermediate altitudes they obtain the same result, showing that the gas is uniformly distributed throughout the atmosphere. (*Z. O. G. M.*, XVII, p. 256.)

164. Müntz and Aubin have presented to the Paris Academy of Sciences the results of observations made on a uniform plan under their directions in various parts of the world on the quantity of carbonic gas in the air. Their method consisted generally in making careful analyses at the seven stations occupied by the French expeditions for the observation of the transit of Venus; they also secured from each station a series of glass vessels filled with samples of the air, all of which were analyzed at Paris by the authors. It is easily seen that the proportion of carbonic gas is not very different at these stations and at Paris, and that the variations everywhere depend on the condition of the sky and the velocity of the wind; the general mean is 2.78 in

10,000 parts of air, which is somewhat smaller than has been found for France and the summits of mountains in France, so that they conclude that the general mean value of the carbonic acid in the whole atmosphere is somewhat smaller than had hitherto been assumed from observations in Europe. (*Z. O. G. M.*, XVIII, p. 473.)

165. Müntz and Aubin have studied the observations made by the French International Expedition to Cape Horn with reference to the quantity of carbonic gas in the air. They desired to test the theory of Schlössing, according to which there should be less CO_2 in the southern hemisphere because of its absorption by the cold ocean water. The results of the observations which were made by Dr. Hyades have convinced Müntz and Aubin that the mean value 2.56 in 10,000 for the southern hemisphere, as compared with 2.84 for the northern hemisphere, confirms Schlössing's theory. They also find that the mean of the measures taken at night-time is slightly less than the average for the day-time, which agrees with the theory requiring the colder waters to absorb more of the gas. This view is confirmed by grouping the measurements according to the observed temperature, from which they find the average 2.530 parts of CO_2 for temperatures lower than 5°, and 2.598 for temperatures above 5°. (*Z. O. G. M.*, XIX, p. 462.)

166. A. Woeikof remarks upon some desultory observations of Professor Tyndall that these do not demonstrate the transparency of dry air to radiant heat; on the other hand, his exposed thermometers over the snow must have fallen into a lower temperature, because the snow itself possesses a great radiating power, and is, moreover, a poor conductor. That aqueous vapor must exert some influence on the absorption of radiation will be admitted by all; the opponents of Professor Tyndall for these many years past have simply affirmed that its influence is by no means so large as Tyndall claims. (*Z. O. G. M.*, XVIII, p. 275.)

167. A. Woeikof also shows that Tyndall's views are inconsistent with well-established meteorological facts in dry climates. (*Nature*, XXVII, p. 460.)

168. J. M. Pernter comments on Professor Tyndall's recent renewal of his conviction as to the extreme efficacy of aqueous vapor in absorbing radiant heat, and makes the following points:

1. Langley's measurements and Abney's demonstration that the vapor in the atmosphere does not exert upon the dark heat rays the absorbing power that Tyndall thinks, that on the contrary the bright part of the spectrum experiences the greatest absorption. Abney's, Festing's, and Becquerel's photographs of the solar spectrum give the direct demonstration that it is fluid and not gaseous water that exert a sensible absorption on the ultra-red.

2. Tyndall's idea that the aqueous vapor prevents loss of heat by radiation from the earth's surface is completely answered by other explanations of the same phenomena.

3. With reference to the elegant experiment of Tyndall's with the

radiophone, it has been shown by Maccaluco and Grimaldi that the glass surface itself is the cause of the phenomena and not the intermediate moist air.

Although the question whether the aqueous vapor absorbs dark heat rays is now decided in the negative, still many questions remain for the meteorologists with reference to the absorption of the solar rays in the atmosphere, especially such new questions as the following: How is it with the absorption of bright rays by the atmospheric vapor? What is the normal atmospheric absorption, when there is no fluid water suspended in the air? How great is the influence of the vapor for different atmospheric conditions? What part is played by carbonic acid gas, and what by the suspended solid impurities called dust? All these questions await their solution, and can only then be brought to a satisfactory solution when in some favorable climate simultaneous observations are made like Langley's and Abney's during a long period of time at a summit and base station. Why should not this be a proper work for the new observatory upon Mount Etna with Catania for a corresponding station?

169. [It is proper here to remark that in view of the probable future importance of this class of observations, and at the suggestion of Professor Langley, the region surrounding Mount Whitney in California has been set apart as a public reservation and assigned to the Chief Signal Officer of the Army for his use; it is probable that it will be occupied as a special signal station at some time in the future.] (*Z. O. G. M.*, XVIII, p. 277.)

170. The Daily Weather Report of the London Meteorological Office for October 1, 1884, states that observations made by navigators crossing the Atlantic, on the temperature of the ocean surface water between Great Britain and Newfoundland, show that during the summer of 1884 the ocean temperature in the course of the Gulf Stream was abnormally high, namely, general average of 3° in June and $1^{\circ}.5$ in July above the normal. (*Nature*, XXX, p. 545.)

171. The Hydrographic Office of the United States Navy publishes monthly charts of ocean currents, ice, wrecks, &c., showing the latest information, as also the prevalent normal condition. This is a very valuable contribution to both navigators and students of the ocean.

172. Dr. O. Pettersson, as a part of the report of the Norwegian North Sea Expedition, investigates the constitution and properties of sea-water and sea-ice. He finds the ice frozen out of sea-water to be not necessarily pure, but a compound of the cryohydrates discovered by Professor Guthrie; the sea-water ice is rich in the sulphates, and the remaining brine richer in chlorides. The latent heat developed by the freezing of sea-water is extraordinarily inferior to that of pure water; the contraction of sea-water ice with heat, as the melting point is being reached, becomes more marked the greater the quantity of salt in the ice. (*Nature*, XXVII, p. 418.)

V.—(*a*) SOLAR RADIATION AND ATMOSPHERIC ABSORPTION; (*b*) TEMPERATURE OF THE AIR, THE WATER, AND THE GROUND.

173. Hirn proposes an apparatus for determining the total absolute amount of solar heat on the principle of the surface condenser of the steam-engine, namely, a saturated vapor contained within a closed receiver has the tension corresponding to that for the lowest temperature of any part of the walls of the receiver. Hirn fills a copper cylinder with bisulphide of carbon, the evaporation of which by solar heat fills a space within which is a cooling surface; the liquid cooled upon this flows into a receiver and is measured. (*Z. O. G. M.*, XIX, p. 548.)

174. Prof. Balfour Stewart, secretary of the committee appointed by the British Association for the Advancement of Science to consider the best methods of recording the direct intensity of solar radiation, reported at the Montreal meeting in 1884 that the committee has chiefly devoted its attention to the subject of a self-recording actinometer. It was suggested that a modification of Stewart's actinometer might be adapted to self-registration by taking for the quantity to be observed, not the rise of temperature of the inclosed thermometer after exposure for a given time, but the excess of its temperature when continuously exposed over the temperature of the envelope. Professor Stokes showed that in such a static method the inclosure should be of such a nature as to change its temperature very slowly, and that the various portions of the interior should be at the same time of the same uniform temperature. The committee therefore proposed to make an inclosure of successive layers of polished plates and some non-conductor; in the center of this is placed a thermometer of green glass with a flattened bulb, on which the sun's light falls continuously, while in the inclosure near by, but unaffected by the direct sunlight, is a second thermometer.

175. [This proposed arrangement for continuous self-registration apparently embodies the same principles that are incorporated in Violle's absolute actinometer, where the object sought by Professor Stokes's arrangement is perfectly attained by using a jacket of circulating cold water.] (*Nature*, XXX, p. 498.)

176. J. Ericsson, of New York, describes a motor for utilizing the sun's radiant heat. This device is less expensive than others hitherto described, and was able to generate steam enough to work a steam-engine of 6-inch cylinder and 8-inch stroke, under a pressure of 35 pounds per square inch, at the rate of 120 oscillations per minute. He reasserts his belief that the solar temperature cannot be less than 1,000,000 degrees Fahrenheit. (*Nature*, XXIX, p. 217.)

177. J. Ericsson describes some of his results on the heat of the solar rays as determined by a large solar pyrometer. His computed temperature of 3,000,000 depends upon the assumed law of radiation, but the apparatus and observations have some good features. (*Nature*, XXX, p. 467.)

178. Dr. Maurer contributes to the *Archives* of Geneva a study upon the theory of the absorption of the solar rays by the atmosphere. He attempts to compute more accurately the thickness of the stratum traversed by the rays at any altitude; his figures are slightly larger than those of Laplace, but they are still not beyond criticism. (*Z. O. G. M.*, XIX, p. 203.)

179. Prof. S. P. Langley, of Allegheny Observatory, has finally published the full text of his extensive researches into solar radiation and atmospheric absorption as a professional paper of the Signal Service. Preliminary to this full publication, he has communicated some of his results to the scientific world through the *Philosophical Magazine*, the *Comptes Rendus*, and the *American Journal of Science;* a Memoir bearing on the same subject also appears in volume 2 of the Memoirs of the National Academy of Sciences. In general he finds the following points established:

1. After the passage of the solar rays through the atmosphere the maximum of heat in the diffraction spectrum lies near the wave-length 0.0006 of a millimeter, and therefore in the orange portion, agreeing with the maximum intensity of light.

2. Before its passage through the atmosphere the maximum of heat intensity was near the blue.

3. The red and ultra-red rays, especially the latter, suffer the least absorption by the atmosphere, while the blue and ultra-blue suffer the most.

4. The energy in the solar rays, before entering the atmosphere, is 1.569 times the energy for a vertical sun after passing through the atmosphere, but this latter corresponds to 1.81 calories, wherefore the true solar constant is 2.84 calories, and Langley believes that the correct value may even be 3. (*Z. O. G. M.*, XVIII, p. 233; and *Signal Service Professional Paper* No. XIV.)

180. O. Frölich contributes to the question of the constancy of the solar heat an important series of observations made with apparatus of his own invention, being a modification of the thermopile, with which he conducted his investigations into the temperature of space and of the sky. As a constant source of heat with which to compare the radiation from the sun he used a surface heated to a temperature of 100° C. His observations were made in September, 1879, on the summit of the Faulhorn, in Switzerland; in the winter of 1879–'80, at the Royal Observatory at Berlin; then, to the end of 1882, at the villa of G. Hansemann; and in 1883, in a tower at West-end, near Berlin. This constitutes the most extensive series of observations hitherto available, and they have been discussed with great care. Among his results we quote the following:

In a perfectly clear sky the atmosphere absorbs a variable quantity, as shown by the variations in the so-called atmospheric constant, which has the least value on the 15th of October and the greatest on the 12th

of September, the zenithal absorption being 29 per cent. on the latter day and 15 per cent. on the former, and this is the more remarkable because the air was more decidedly hazy on the 12th of September.

By observing the temperature of a point in the same vertical plane with the sun but on the opposite side of the zenith, one should theoretically have the means of determining the influence of the atmosphere, but his efforts to realize this method have shown that it is not successful in the latitude of Berlin, partly because the observations are not so accurate, and partly because the atmospheric irregularities have a larger influence.

In general, in the day as well as by night, the lowest temperature is found in the zenith and the warmest towards the horizon. This, which is due to the sky temperature, is apparently exaggerated by the sun's heat without a material change in the relative temperatures.

The diminution of solar heat with the length of path through the atmosphere is such that the former is a linear function rather than a logarithmic function of the latter.

The observations on the Faulhorn show that the atmospheric constant for that elevation is sensibly smaller than in Berlin.

The most important result of the work is the proof that the solar heat is not constant, but subject to very considerable variations, as shown by the following values of the "solar constant":

For June 29	574 ± 18
For July	564 ± 15
For August 14	607 ± 18
For September 12	573 ± 51
For October 15	555 ± 19

The probable errors here given are really three times the probable error as ordinarily understood, and represent the limits within which the probabilities are 22 to 1 that the true value must fall. In general the change of solar heat is such that it increases by about 6 per cent. from the 1st of July to the middle of August, and then diminishes by about 8 per cent. by the middle of October. This change is entirely parallel to the observed change in the development of sun-spots, as recorded by the observers at Potsdam, who state that at the beginning of July and in September and October the development was quite rapid, but in August much less, whence we may hope that this method of observing the solar heat may give a method of inferring the variations in the sun-spots.

The importance of this variation in solar heat may be estimated by the following considerations: The mean temperature of the ground at any place on the earth's surface is the result of two factors, namely, the mean influence of the heat from the sky and that of the heat from the sun. The first of these, according to the Königsberg observations, amounts to $-82°$ for that place, and the latter influence amounts to $+89°$ C. We may therefore assume that in temperate latitudes a change of solar

heat of 1 per cent. corresponds approximately to a change of ground temperature of 1° C. The variations above found by Frölich would, therefore, if they endured for any length of time, produce a change in the earth's temperature of six or eight degrees.

181. [It is certainly very desirable that Frölich's observations should be maintained continuously at several stations on the earth's surface where atmospheric changes are comparatively rare, as it is scarcely possible to think that we shall ever master the peculiarities of meteorology until we thoroughly understand the variations in the prime factor of all—the solar heat.] (*Z. O. G. M.*, XIX, p. 209.)

182. Dr. H. C. Vogel, of Potsdam, comments upon these results of Frölich's and maintains that the observations do not distinctly show changes in the solar heat that are appreciable in comparison with the uncertainty of each day's observations; that possibly in time one may accumulate sufficient observations by Dr. Frölich's method to detect the short variations, but that five days of observations are not sufficient. With reference to Frölich's opinion that variations in the solar heat, if any exist, have some connection with the size and number of the sun's spots, Vogel states that accurate measures of the sun-spot area in April, 1882, on a day that was specially rich in spots, showed that the solar heat could only have been diminished by about four-tenths of 1 per cent. The observations made at Potsdam on the very days of Dr. Frölich's observations show that the influence of the few spots then visible must have been extraordinarily small, and that his temperature observations must have at least ten times greater accuracy than now before he can detect such influence. (*Z. O. G. M.*, XIX, p. 259.)

183. Dr. O. Frölich, in some remarks on methods of measuring solar heat, states that he cannot agree with Langley in the assumption that the atmospheric coefficient of absorption is proportional to the barometric pressure, nor with his conclusions that the logarithmic law holds only for homogeneous rays and not for the whole spectrum. Frölich's investigation of the absorption due to the altitude of the sun has the advantage of Langley's, in that the latter uses only two observations at different altitudes while the former uses from four to fifteen. Frölich also doubts the accuracy of Langley's reduction to a standard measure. He proposes to explain the movements of the granite pillar observed by Förster (see chapter XII) as due, not to a change in the amount of solar heat, but to a change in its character such that at the time of the solar spot frequency the earth or the pillar absorbs relatively more or less heat. Frölich defends himself against the criticisms of H. C. Vogel to the effect that he has not been fully on his guard against constant errors by referring to the fact that the most important novel feature of his work lay in the constant reference to a normal standard, and that nothing can diminish the certainty of the conclusion that his observations demonstrate a sensible variation of solar heat during August. In reference to the possibility of detecting changes in the sun's

heat by Langley's, Förster's, and Frölich's methods, he recognizes that Förster's granite pillar has a much more constant sensitiveness and certainly changes very slowly; he has therefore undertaken a modification of his own apparatus looking to an independence of the variations of the temperature of the air. (*Z. O. G. M.*, XIX, p. 400.)

184. Dr. W. Köppen publishes an interesting study of the effect of hot, temperate, and cold weather on the organic world, and proposes a new distribution of the limits of temperate zones, namely, the *tropical zone*, where every month the temperature is above 20° C.; the *subtropic zone*, where four to eleven months are hot, or above 20°; the *temperate zone*, where from four to twelve months are temperate, namely, from 10° to 20°, and this he divides into three subzones, the *uniform temperate*, having hot summers and cool winters or temperate summers and cold winters; the *cold zone*, where from one to four months are moderate and the remainder cold; and the *polar climates*, where all months are cold, namely, under 10° C. He shows that this empirical division (lower than 10°, from 10° to 20°, and above 20° C.) accords reasonably well with phenomena of animal and vegetable life. Everywhere the progress of civilization has been from the warmer into the cooler countries. (*D. M. S.*, I, p. 215.)

185. Dr. A. Woeikof, on the dependence of the daily variations of temperature upon local circumstances, especially topography, formulates his views about as follows:

1. A convex surface, such as a hill or mountain, is a cause that diminishes the daily range of temperature, and by so much the more in proportion to the ratio of the vertical to the horizontal dimensions.

2. A concave surface, as a valley or hollow, increases the daily range of temperature, but only up to certain limiting ratio of vertical and horizontal dimensions.

3. As a normal condition in respect to the daily amplitude he adopts a perfect plane surface; he gives numerous examples of this, quoting the data from Asia and Europe; he eliminates the effect of cloudiness and winds, and leaves the outstanding daily amplitude to be explained as due to the influence of the topography. Quantitatively it would seem that the daily amplitude in the high valleys of the Indus, 3,500 meters above the sea, in January and February, is greater than in some of the driest places on the low plains of Northern India. (*Z. O. G. M.*, XVIII, p. 211.)

186. G. J. Symons gives the first results of simultaneous thermometric and hygrometric observations at heights 4, 170, and 260 feet, which were made on behalf of the Royal Meteorological Society on the cathedral tower at Boston. During clear November weather the average temperature at the highest point was greater than at the earth's surface by reason of the excess of cold due to radiation at night, but on cloudy, windy weather, the average temperature was lower above than below. In foggy weather the temperature at the highest point was always higher

than at the earth's surface, but this is explained by the fact that generally the fog did not reach up to the higher point. (*Z. O. G. M.*, XIX, p. 84.)

187. Professor Wollny, investigating the influence of the ground upon the temperature of the air, especially for altitudes up to 2 meters, shows that the air above a field covered with vegetation is materially cooler than that over one lying fallow, and again that the variations of temperature above the former are less than above the latter. This he explains as due to the fact that the vegetation prevents the direct warming of the soil by the sun; and even more important is the consumption of heat in the evaporation of water at the surface of the leaves. Similarly at night time the plants prevent the cooling of the earth's surface by radiation during clear weather, and on the other hand themselves give out an extraordinary amount of heat, whereby the cooling of the air is made still less. Even this cooling process is, however, checked by the formation of dew and the evolution of latent heat. The difference in temperature over cultivated and uncultivated land diminishes in proportion as the evaporation by day and the radiation by night are modified; therefore it almost disappears in the winter season or in severe droughts, and especially in cloudy weather. (*Z. O. G. M.*, XIX, p. 539.)

188. Dr. E. Lamp, of the Kiel Observatory, quotes observations showing that it is not at all necessary, as frequently implied, that the temperature should be uniform in different portions of a fog. Thus he observed in a thermometer shelter +2°.2 C.; in the free air near by +1°.8; at the summit of the wind tower [for anemometer exposure?], +4°.2; at its bottom, +2°.6; at the base of the observatory hill, —0°.2; on the side of the hill rapid variations of temperature within five minutes from +2°.0 to +0°.5. The observations were not taken with a sling-thermometer, as would have been preferable. (*D. M. Z.*, I, p. 474.)

189. [These, like the numerous observations made by Prof. H. A. Hazen in various parts of Washington, show that great local temperature differences invariably exist, so that the meteorologist, in choosing the exposure for his thermometer, must be guided by the object of investigation or the use to which his figures will probably be put. At Columbus, Ohio, Louisville, Ky., and Davenport, Iowa, differences, on cold, clear nights, of 25° F. have been observed. The Signal Service rule (partly necessity and partly justified by the results) is to place the thermometer shelter on the highest available point, like the roofs of houses or towers, in the cities where the stations must do their work. The local difference of temperature of the air over cities and forests and prairies is in this way reduced to a minimum in the daily telegraphic work, and we attain for general weather predictions the average temperature of the mass of air blowing past the station. Were any other, especially any very low-ground exposure adopted, it would be proper and necessary to reduce such observations up to the uniform height of about 100 feet above the surface of the ground.]

190. A. Buchan has published in the *Journal of the Scottish Meteoro-*

logical Society a revision of his work on the distribution of temperature over the British islands. All the data accessible to him have been reduced uniformly to consistency with the twenty-four-year interval, 1857 to 1880, inclusive. The isotherms of January show distinctly the inclosed cold area in the northern part of Iceland and the northeastern third of Great Britain. The winter temperature diminishes as we proceed inward more rapidly than would correspond to elevation only. The influence of the prevailing west-southwest winds is, of course, to bring the warmer ocean temperatures up over the land, and an elevation of a few thousand feet would cover the British isles with glacial snow. The remarkable difference between the Scottish and Welsh highlands is clearly seen in the dry, cool air of the Scotch, and the warm, moist atmosphere of the Welsh. (*Z. O. G. M.*, XVIII, p. 401.)

191. A. G. Högbom has studied the change in isotherms in the autumn over Northern Europe in a manner corresponding to Hildebrandsson's study of isotherms for the spring. His tables show that the advantage of a maritime climate and the disadvantage of a continental climate on the growth of vegetation are more marked in the autumn than in the spring. (*Z. O. G. M.*, XIX, p. 112.)

192. Prof. H. Riesenberger has, at his own expense, carried out temperature observations at three mountain stations for comparison with observations made by himself at Hermannstadt. The altitudes of the four stations are, respectively, 411, 953, 1,318, and 1,598 meters. The diminution of temperature with altitude is very slow, corresponding to that found on plateaus rather than on mountains. In December the diminution occasionally becomes an increase. The rate of diminution has also a large daily period, it being slowest at 7 A. M., when it is 1° C. for 456 meters, while at 2 P. M. it is 1° for every 144 meters. (*Z. O. G. M.*, XIX, p. 456.)

193. Dr. A. Lugli has investigated a formula for expressing the connection between the monthly and annual mean temperature in Italy with the latitude and altitude above sea-level. He finds for the stations of the Apennines and those south of the Alps as well as the low stations the following formula for the mean annual temperature: $t=13^\circ.86 + 0^\circ.67(45^\circ-\psi)-0^\circ.0055\,h$. He then examines the mean temperatures for each month, and determines for each the special values of the three constants in this formula, which vary as follows: The change of temperature for 1° of latitude is a minimum in the summer, having an average value of 0°.30 for April, May, June, and July; it is a maximum in winter, having a value of 1°.36 for December. The diminution of temperature for 100 meters of ascent has an average value of 0°.51 for the year, the maximum being 0°.64 for April, and the minimum 0°.36 for January. The author then combines the highest Alpine stations with those in his sub-Alpine districts, and with these again revises his calculations, deducing general values, representing especially the conditions for the latitudes 39°.4, and 45°, respectively. The mean annual change for a degree of latitude at 45° is 0°.72 C, and for 100 meters of

ascent 0°.52 C. At 31°.4 the change for latitude is 0°.56, and for altitude 0°.58. (*Z. O. G. M.*, XIX, p. 459.)

194. [Similar computations for the Rocky Mountain and Plateau regions of the United States, as made by Prof. W. Upton, will be found in the Annual Report of the Chief Signal Officer for 1882, and afford interesting bases for comparisons with the above Italian observations.]

195. O. Doering has investigated the variability of the temperature in the Argentine Republic and South America, following out the suggestions in Hann's memoir of 1875, on the variability of daily temperatures. Doering utilizes twenty years of observations at Buenos Ayres. His figures give the mean variability as depending upon non periodic temperature changes for the individual months and years. Sudden changes upward are more frequent than falls in temperature. Ten days of more than 5° change are likely to occur in a year. The north wind brings the greatest rise in temperature, the southeast wind the least. With regard to falls in temperature, these come with southerly winds, and are preceded by northerly winds. The greatest falls in temperature occur without rain more frequently than with rain. (*Z. O. G. M.*, XIX, p. 507.)

196. Sir G. B. Airy compares the temperatures of the water of the Thames with the corresponding temperature of the air; he finds that the water averages 1°.5 F. higher than that of the air according to the Greenwich thermometers; the mean diurnal range of water temperature was 2°.1 F. (*Nature*, XXVII, p. 129.)

197. Prof. von Miller-Hauenfels states that the curvature upward of the isothermal surfaces inside of a mountain mass has lately been quoted as an argument against the melted condition of the earth's interior, but it seems to him that, independent of any view that one may have with regard to this source of heat, such an upward curvature of the surfaces must take place under any circumstances. In general, temperature increases toward the center of the earth, but with a rapidity variable according to the time of the year. Now, according to well-known laws, the transmission of heat upwards must take place in directions normal to the surface, and these normal lines being perpendicular to the surfaces of equal temperature, the latter must necessarily rise up in the interior of a mountain mass. (*Z. O. G. M.*, XIX, p. 297.)

198. Prof. W. Schwalbe communicates to the Physical Society numerous observations as to the formation of natural ice caves, and maintains that a sufficient explanation of this phenomenon has not yet been offered. (*Nature*, XXVII, p. 380.)

VI.—(*a*) EVAPORATION; (*b*) ATMOSPHERIC MOISTURE; (*c*) CONDENSATION, FOG, AND CLOUDS; (*d*) RAIN, SNOW, HAIL, DROUGHT, AND FLOOD; (*e*) AMOUNT OF CLOUDINESS AND SUNSHINE.

199. Professor Ragona, of Modena, presents the results of observations upon evaporation since 1872. He finds no well-marked daily period, probably owing to some peculiarity of his apparatus. The an-

nual maximum takes place on the 25th of July, and the minimum on the 20th of January. He finds a negative evaporation during the winter months, which must be an error in his instruments unless, indeed, the deposit of fog and dew is extraordinarily heavy. He finds the ratio between the evaporation in perfectly free spaces and that from an evaporimeter established in an ordinary thermometer shelter to vary between one and three. (*Z. O. G. M.*, XVII, p. 242.)

200. [The relative amounts of evaporation from snow, ice, fresh and salt water, in full sunshine and cloud, calm and wind, is a matter that still needs to be well determined.]

201. Dr. J. Hann, in his new edition of Jelinek's Instructions for taking Meteorological Observations, has introduced tables for the convenient computation of the quantity of vapor contained in any atmospheric strata as well as its influence on barometric hypsometry. He first states that the formula published by him ten years ago still represents more recent observations in the higher atmospheric strata. He then applies this equation to the computation of the probable moisture at elevated stations in Austria, Italy, Ceylon, Java, England, Switzerland, and shows that wherever we have observations the prediction by means of this formula is well verified, so far as regards monthly and annual or even weekly averages.

This reliability justifies us in using the computed values of vapor tension when actual observations are missing. The effect of this moisture upon the barometric computation of altitudes amounts to as much as 17 meters for an altitude of 2,000 meters in a moist, warm climate like Ceylon, but only 6 meters in a cooler climate, such as Switzerland; in both cases the correction for vapor gives higher altitudes.

The effect of vapor in diminishing the density of the air, thus giving rise to ascending currents, is sensible, but very slight in comparison with the effect of ordinary changes of temperature; thus the entire vapor in a mass of air 2,000 meters deep is only equivalent to the influence of a change of 1°.3 C. in temperature, and, as the temperature changes may easily amount to ten times this figure, they are relatively much more important.

By integrating the proper equation Hann deduces the formula for computing the weight of water in a column of air of any height, whence, of course, the amount contained in the whole earth's atmosphere can be deduced. (*Z. O. G. M.*, XIX, p. 128.)

202. W. Köppen describes the process of growth of a cumulus cloud in the warmest part of the day. He finds that the highest point moves forward more rapidly than the lower part of the cloud; that this disappears little by little, while a lower portion of the cloud has risen up to the same height; this again in its turn disappears, to be replaced by the upgrowth of a next lower portion, and so on. He explains this as due to the fact that the cumulus is really the head of an ascending mass of moist air, and is driven along by winds that have a greater velocity

above than below. On the other hand, it will occasionally happen that the upper currents are slower or reversed, in which case the summit of the cumulus follows instead of preceding the main cloud. (*D. M. Z.*, I, p. 29.)

203. [Two facts not mentioned by Köppen should be remembered in order to achieve a fuller explanation of cloud phenomena, namely, that the upper part of the cumulus cloud is surrounded at a little distance by the drier air into which it has risen, which, therefore, tends to evaporate and dissipate the surface of the cloud; and, again, the powerful effect of the solar rays (which increases slightly with altitude) is to evaporate the moisture at the surface of the cloud and to surround the whole sunny side of the cloud with a thin layer of hot moist air, which must have a special ascensional tendency. This action of the sun is undoubtedly also very efficacious on the upper surface of extensive layers of stratus clouds from which vapor currents rise, which in turn form a second layer at some distance above, while the density of the whole mass of warmed cloud and air is diminished, and an additional ascensive tendency is felt at the earth's surface over a large and extended territory.]

204. The increasing interest in the observations of clouds has led van Bebber and Köppen to attempt a system of corresponding observations, which were planned after consultation with Dr. Klein and Möller and Assmann. The same methods of description are used at all stations, and the complete record of clouds is made a part of the regular entries in the daily journal as well as in the special records. (*D. M. Z.*, I., p. 36.)

205. Rev. Clement Ley, in an essay on the structure of the cirro-filum, or thread-like clouds, presumably formed of ice spiculæ, states that this is one of the most important forms in the prediction of the weather; he has observed it for twenty-five years, and offers a classification of the more reliable observations and an explanation of some of the more prominent phenomena. His classification of the clouds relates to their form, their structure, and their relations to each other. The following three generalizations seem to him of importance:

1. If we turn the face toward the wind as we stand on the earth's surface, then in the majority of cases the upper currents of air move from the right to the left.

2. Winds from the west lie above those from the east in the upper regions of the atmosphere much more frequently than is the case at the earth's surface.

3. The upper strata of the air as a rule move much more rapidly than the lower. He gives a table showing the number of cases in which the cirro-filum cloud moves from the respective points of the compass. He restricts the name cirrus to the upper clouds formed of bent or twisted bundles of threads, whereas those composed of long lines or filaments have a much greater velocity, and are characterized by him as linear

clouds, or cirro-filum; of these latter we must distinguish the direction of the motion of individual particles from the direction in which the long threads trend. This latter direction he calls the filature of the threads, and is determined by the location in the horizon of the vanishing point of two or more parallel threads. The apparent velocity is expressed on a scale of 3, namely, 0, calm; 1, slow movement; 2, moderate, and 3, a rapid movement. There is a form of cloud which Ley calls the pseudo-cirrus, which appears at low altitudes, having an apparent rapid movement, and is erroneously taken for true cirrus. He apparently distinguishes one from the other by the rapidity of the movement, and states that he has never seen a true cirrus with a rapid movement. His tables of the results of over 3,000 observations, mostly by himself and friends in England, allow him to conclude as follows:

1. The movements of the cirro-filum are more frequent in the direction of the length than at right angles thereto.

2. The cases in which the vanishing points lie on the right-hand side of the direction from which the clouds themselves move are for north and west movements by far the most frequent, but for south or southeast movements the vanishing points more frequently lie on the left-hand side of that direction.

3. Great velocities of movement are confined to those cases in which the direction of filature nearly or wholly agrees with the direction of motion, and cases in which they are at right angles to each other never occur with great velocities.

The explanation of these rules he arrives at by the study of the lower forms of clouds. He finds that on account of the difference in rapidity and direction of the velocity of different parts of the cumulus clouds, even the lower cumuli manifest a tendency to assume a form that reminds one of streaks and threads. Especially is this the case when streaks of snow falling from the summits of these clouds give rise to what he calls "pseudo-cirrus-pendulus;" these fall at first vertically, but subsequently are deflected or bent and twisted by the movement of the air into which they fall. Now the true cirro-filum is often found on the extreme limit of a cyclone, and therefore several hundred miles from the center, so that it is impossible to observe the process of formation of the whole thread. It happens, however, that in otherwise clear weather a local rain cloud sometimes develops a great quantity of cirri-filum, and then it is possible to observe the process without difficulty. Some miles from the observer on a summer day there forms a heavy cumulus; if, as frequently happens, an almost perfect calm prevails in the atmosphere up to an altitude of 12,000 or 14,000 feet the cumulus retains its hemispherical form, and thus there comes to be an enormous accumulation of cloud that can easily amount to a hundred cubic miles, and its dark color shows that the water-drops of which it consists are very close together. [This statement as to color seems to be rather an assumption than a well-warranted conclusion; do not the size, form, and number of the

drops all contribute to the shade?] So long as such clouds retain their sharp upper limit and their general spherical shape, no rain falls from them. Suddenly the summit has a softer appearance, extends itself sideways in cirrus-like threads, and immediately the rain plunges down out of the cloud. The electric tension which hindered the conjunction of the water particles that form the cloud, so long as they retained their spherical form, is suddenly diminished in the upper part of the cloud as soon as the little spheres freeze into ice needles or spiculæ, from whose points and corners the electricity immediately escapes. [The easy escape of electricity from snow-crystals is a matter which should easily be confirmed by observation; it agrees with the high potential observed during snow-storms.] The minute bodies having lost their electricity, unite and absorb in their rapid descent the smaller particles of water with which they come in contact. [Do the spiculæ and snow-flakes descend rapidly enough to overtake particles of water?] The falling rain, and perhaps still more the sudden lightning, when such occurs, further contribute to draw the electricity from the cloud or lower its electric potential; the rain continues until the whole or nearly the whole lower part of the cloud disappears. In those cases in which not only in the lower but also in the upper strata of the atmosphere only slight movements prevail, the ice-cloud remaining at the summit becomes a true cirrus, whose curled and twisted form is probably a consequence of temporary irregularities in the pressure of the air due to the condensation and formation of ice. A cirrus which is formed in this way remains sometimes more than twenty-four hours almost perfectly without motion in the sky, but more frequently it moves slowly into regions into which the rain-shower out of which it originated has not been visible. If the upper and lower parts of this cloud do not move at the same rapidity it will be drawn out into the long cirro-filum cloud, and this probably often occurs when the upper part of the original cumulus has penetrated some cool upper current of air, whose coolness has, in fact, frozen the vapor into snow. If the motion of the cloud follows the direction of the movement of these threads, or is directly opposed to it, the angle of filature will be zero. The actual filature angle is the resultant of the movement of the upper current carrying the snow crystals in one direction, while the lower current carries the cloud, with its perpetually renewed summit, in another direction; by constructing the triangle or parallelogram of motions, we can thus either construct the resulting, or analyze the observed, filature. The observed result as above given, namely, that the positive angle of filature occurs principally with the movement of the clouds toward north and west, and the negative angle with movemont towards southeast, shows that the upper currents of air are from the north and west when the lower current is from the south or west, so that the axis of the cloud must then deviate from its summit toward the right; on the other hand, southeast upper winds are most

frequent as the immediate followers of southeast lower winds. (*D. M. Z.*, I, p. 261.)

206. [Without in the least detracting from the originality and great value of Clement Ley's laborious observations and well-grounded definite results, it is at least proper to state that on pages 48, 49, and 179 of Espy's Fourth Meteorological Report and in others of Espy's writings will be found results almost precisely the same as those of Clement Ley. The reader who consults this, the last work published by Espy, scarcely a year before he died, will perhaps be glad to have his attention called to Espy's labors subsequent to the publication of his Philosophy of Storms. After returning from Europe, Espy was, in 1842, appointed meteorologist in the office of the Surgeon-General of the Army (General Lawson). His first Meteorological Report, dated October, 1843, and printed in February, 1845, was addressed to Surgeon-General Lawson. His second report, dated November, 1849, was addressed to William B. Preston, Secretary of the Navy, from which we infer that he had been in the mean time transferred to the Navy Department, but I have not yet been able to find that this report was ever separately published. His third report, dated October, 1850, with notes, dated January and October, 1851, and an appendix containing rules to mariners, dated January, 1851, seems to have been addressed to Secretary W. A. Graham, but to have been published by Secretary J. C. Dobbin in 1852, and it was preceded by a reprint of the first and second reports. The fourth report was evidently written originally in October, 1852, but was not forwarded by the Secretary of the Navy until specially called for by resolution of Congress, July 24, 1854, nor was it even then printed until a special order was issued in 1857. In the printing additional notes were evidently inserted, most of which may be considered as dating from 1857. The contents of the resulting quarto volume, usually called "Espy's Fourth Report," and whose title-page bears date of 1857, may therefore be approximately analyzed as follows: First report, of 1843, pp. 1–10; second report, of 1849, pp. 10–40; third report, of 1850, pp. 40–96; appendix to third report, 1851, pp. 97–116; fourth report, of 1852, pp. 117–178; additional notes of 1857, pp. 178–234.

Both directly and indirectly the United States owes to Espy the stimulus and knowledge that made our present Weather Bureau a possibility. In all that pertains to the formation of cloud and rain, the vertical distribution of temperature, the theory of the psychrometer, the diurnal periodicity in the winds, the structure of thunder and hail storms, tornadoes, and general storms, he was far in advance of his time. The republication of his minor works and an analysis of his life and influence would afford a most delightful picture and instructive history.]

207. R. Abercromby contributes a note descriptive of various forms

of festooned or pocky clouds, such as Poey proposes to call *globo-cumulus.* (*Nature*, XXVIII, p. 79.)

208. Mr. John Aitken and Dr. O. L. Lodge have made numerous experiments to elucidate the reasons for the so-called clear spaces which are absolutely free from dust in the neighborhood of solid bodies (the so-called dark plane of Professor Tyndall and Lord Raleigh). They conclude that the dust is repelled from hot surfaces in the same way as the vane of a Crookes radiometer is repelled when placed in front of a hot surface, namely, one hotter than the intervening gas, the principal part of the energy of the motion being given to the repelled surface or dust particle by the kinetic energy of the impinging molecules; the attraction of a cold surface is explained by the less kinetic energy of the outward-going molecules of the hotter gas. A wet and hot surface repelled dust twice as strong as a hot, dry surface. Mr. Aitken, led by these views, constructed a dust trap by means of a tall metal tube surrounded by another larger. The smoke goes up the center tube and down the intervening space; the soot is deposited on the cool inside of the outer tube, so that air can be purified by heating and cooling it a number of times. Dr. Lodge found the dust coat to increase greatly with high temperatures; he rejects the explanations given by Tyndall, Frankland, and Lord Raleigh; he especially examines the effect of convection currents in the air under high pressure, and even in water, and thinks the main causes are the molecular bombardment and the gravitative settling. His complete theory is published in the Philosophical Magazine for March and April, 1884. (*Nature*, XXIX, pp. 322, 417, 611.)

209. Prof. Lodge states that the concentrated radiation from an electric light is much less effective in warming dusty air than is the neighborhood of a slightly warmed solid. (*Nature*, XXX, p. 53.)

210. Mr. E. W. Serrell explains the flotation or buoyancy of cloud particles, and also of dust, as due to adherent, heated, and dilated air, namely, the solar radiation obstructed by the particle, and consequently giving rise to minute convection currents.

211. [The present writer remembers the conversation had with Mr. Serrell in 1880, to which he refers in his letter, wherein I suggested that the flotation of vapor particles at upper surface of clouds in the atmosphere, under the influence of sunlight, was due to their evaporation and heating, by which the whole cloud is more buoyant. This, however, is hardly parallel to the experiments made in a laboratory, where radiation is of much less importance, in comparison with the condition of heat by convection and kinetic molecular processes.]

212. The observations with silk fibers, suggested by Serrell in 1880, seem to have lately been made by Prof. G. F. Fitzgerald, of the Dublin Royal Society. (*Nature*, XXX, p. 331.)

213. On the 28th of March, 1884, Prof. Osborne Reynolds, in a lecture at the Royal Institution, summarized his results up to that time, giving additional new experiments on water and air, which are both

novel in hydro-mechanics and also extremely suggestive to the students of atmospheric motions and cloud formation. (*Nature*, XXX, p. 88.)

214. G. H. Darwin communicates to the Royal Society of London an extensive paper upon the formation of ripple marks in sand. This is not only a very suggestive phenomenon in hydrodynamics, but, as the author suggests, may possibly have a bearing on the mode of formation of the "mackerel sky" and other forms of cirrus. [As regards the formation of the long cirrus threads, we should prefer the explanation by Rev. Clement Ley to that given by Darwin.] (*Nature*, XXIX, p. 161.)

215. Prof. J. W. Mallet has made an extensive compilation of data relating to the analysis of drinking-water and rain-water, which is published as a report to the United States National Board of Health.

216. A. von Danckelman, of Leipsic, has investigated the observations of precipitation made in Saxony, 1864 to 1881. Among his results we quote the following:

The maximum probability of rain (0.63) falls in the decade March 2 to 11; also June 30 to July 9, and November 27 to December 6. The minimum probability (0.40) occurs in the decades September 28 to October 7, and May 11 to 20.

The relative number of days of snow and days of rain are in the winter 56, spring 22, and autumn 13 per cent. The number of days free from snow varies from 204 at one station to 157 at different stations. (*Z. O. G. M.*, XVIII, p. 392.)

217. Dr. J. Müller gives a very complete collection of the results of observations of rain and snow in Switzerland, some of the longer series representing sixty years of observations. The region of greatest summer rain is on the northern side of the Alps; in this region the winter and autumn rains increase from east to west, but the summer rains diminish; the region of minimum rainfall embraces the Canton of Tessin. (*Z. O. G. M.*, XIX, p. 343.)

218. Professor Töpfer has published an elaborate investigation into the rainfall of Germany, which is printed by the association at Gorlitz. He finds that the upper stations have a much more uniform distribution of rain through the year. The heaviest rainfall in stations of long series occurred at Klausthal and Freudenstadt and the summit of the Brocken; the least occurred at Wustrow and Muhlhausen. (*D. M. Z.*, I, p. 258.)

219. E. Millosevich has published an exhaustive monograph on the distribution of rainfall in Italy. Italy possesses many stations having very long series of observations on rainfall; for instance, Padua, 155 years; Milan, 116; Verona, 81; Palermo, 74; Pavia, 63; Naples, 59; Rome, 55; &c. These, therefore, give the author opportunity to study not only the geographical but also the chronological distribution and periodicity. In a land of such varied topography the variations of climate are so great that it would be impossible in the present summary to give any idea of the richness of the storehouse of information contained in this volume. (*Z. O. G. M.*, XIX, p. 49.)

220. Dr. V. Kremzer has studied the variability of rainfall in Europe, following the path of Hann, von Danckelmann, and others. Among the general conclusions to be drawn from his tables we note the following:

1. The mean variability in quantity of rainfall increases with diminishing latitude, and the more rapidly in proportion as we penetrate the region of subtropical rains.

2. From the records for Padua for 150 years he finds that the error of the mean annual rainfall as computed for any 30 years will be 1 per cent. and the largest probable error 2.5 per cent.

3. The sources of variation in rainfall measures due to changes in the observers, in the exposure of gauges, and in the general changes of the regions surrounding the gauges, are all included in the above figures for the actual rainfall; he makes a special illustration of the effect of these sources of error in the case of the records at Breslau, where the great mean variability and annual variability is largely traceable to instrumental changes.

4. As to stations that lie in the rain shadow of a mountain chain, they also have a higher variability because of this location than do those stations that lie on the opposite side of the mountain and receive an excess of rain. In this respect he examines especially the records from Italy and the Hartz Mountains.

5. In reference to elevation above sea level, the variability of rain is much less for an entirely plane surface considerably elevated above the sea, but the contrary if mountains intersect an elevated plain. As regards the relation between coast and interior stations, the former have the greater variability.

6. As regards the seasons, the greatest variability belongs to the cold season of the year, while the least variability or greater uniformity belongs to the season of vegetation.

Kremzer gives convenient general tables for deducing the number of years of observations necessary in order to obtain an annual mean of a given accuracy; thus for a station whose annual variability is 20 per cent., 11.8 years will be required to obtain a mean rainfall correct to within 5 per cent. The probable errors of the monthly rainfall for any one station as based on observations for 10 years are as follows: For Algiers 22 per cent., southern Spain 19, lower Italy 18, Central Italy 16, upper Italy 15, Switzerland 14, Germany 12 and 11.

The above remarks refer to percentages of rainfall, taking the annual and monthly mean total quantities as the basis; in a subsequent section on the actual rainfall he discusses the occurrence of dry and wet periods. By combining together all his rainfall records for Europe, he obtains a general mean which must have some cosmic or extended terrestrial relation. Combining each year with its neighboring years he obtains a smoothed curve, which is expressed in the second column of the following table in percentages of the departure of the quantity of rain from its

normal value. The wonderful agreement of these variations with the variations of Wolf's sun-spot numbers shows that we have here to do with some general feature connecting the earth and sun, the inflections of the rain-curve following those of the sun-spot by an interval of about one year.

Kremser's variability of rain in Europe.

Year.	Per cent.	Year.	Per cent.	Year.	Per cent.
1848	+3.8	1857	−8.9	1866	0.4
1849	3.7	1858	−7.1	1867	4.7
1850	4.5	1859	−1.6	1868	4.8
1851	5.2	1860	+2.2	1869	+1.6
1852	4.5	1861	+1.9	1870	0.0
1853	2.9	1862	0.5	1871	1.7
1854	+1.6	1863	−3.8	1872	3.1
1855	−0.9	1864	−6.2	1873	+2.5
1856	−5.5	1865	−4.6	1874	−0.2

(*D. M. Z.*, p. 93.)

221. G. J. Symons, of London, gives an important discussion of the variation in annual rainfall for the years 1830 to 1881 in England. The mean of nine stations is reduced to annual percentages, the extreme range of which is from 71 per cent. in 1854, up to 136 per cent. in 1852. From 1853 to 1859, inclusive, the rainfall was below the average; from 1875 to 1881, it was decidedly above the average. Hann remarks that this dry period prevailed also on the northern side of the Alps, while the wet period prevailed over the whole of Western and Central Europe. The very dry period that prevailed in Hungary, 1861 to 1866, was not prominent in England. In general, the average variability of English rainfall is about 14 per cent. of its mean quantity, but it amounts to about 40 per cent. each half century. The wet and dry years apparently arrange themselves in series of ten and twelve years respectively; thus the wet years are 1836, 1848, 1860, 1872; the dry years are 1834, 1844, 1854, 1864, and 1874. (*Z. O. G. M.*, XVIII, p. 387.)

222. F. Augustin has studied the rainfall at Prague, especially as to its daily periodicity, having at his disposal twenty years' observations with a self-recording rain-gauge; he finds it impossible to give the mean annual periodicity, especially because of the difficulty of measuring the snow in winter time, and the loss of occasional very heavy rainfalls in summer time, but the daily maxima and minima stand forth very clearly. As regards quantity of rainfall, the principal maximum occurs between 4 and 5 P. M., shortly after the temperature maximum. A second maximum occurs between 9 and 10 P. M.; a third maximum between 9 and 10 A. M. The principal minimum occurs about 4 A. M., a second minimum between 7 and 8 P. M., and a third minimum between 11 A. M. and noon. With regard to the frequency of rain, there are also three maxima and three minima, as follows: The principal maximum, 7 to 8 P. M.; the secondary maxima, between 8 and 9 A. M., and between 2 and 3 P. M.; the principal minimum, between 2 and 3 A. M.; the secondary minima, about noon and between 4 and 5 P. M.

The intensity of the rainfall or the quantity per hour changes very nearly as the total quantity; the probability of rain follows the curve of rain frequency. (*Z. O. G. M.*, XVII, p. 243.)

223. F. Seeland, of Klagenfurt, has studied the daily record of the height of water in the wells fed by subterranean springs at Klagenfurt during the five years 1878 to 1882; the height of water is, of course, a general result of the rainfall of the whole of the surrounding basin, which extends from northwest to southeast. All the springs in this basin show similar phenomena; the lowest average reading prevailed in 1878; the highest in 1879. Comparison with the rainfall at one station, Klagenfurt, scarcely gives any satisfactory basis for unraveling the complicated phenomenon. The highest rainfall occurred in 1787 and the least in 1881. (*Z. O. G. M.*, XVIII, p. 339.)

224. H. F. Blanford, director of the Meteorological Office in India, from a study of the connection between snowfall in the Himalaya and the subsequent dry winds of Northern India, draws the following conclusions:

1. A remarkably heavy and especially a late snowfall in the Northwest Himalayas is followed by a long period of drought on the plains of Northwest and Western India.

2. A rich winter and spring precipitation at the stations of the Northwestern Himalayas is followed in sixteen cases out of eighteen by a deficient summer rain on the plains of Northwest India, and *vice versa.*

3. The west winds that are characteristic as abnormal during droughts in west and north India are identical in character with the normal winds of the regular dry season, and appear to be fed by descending currents from the Northwest Himalayas and possibly from the mountains on the west.

4. It is an ordinary well-known phenomenon of the winter months that a fall of rain and snow in the Northwest Himalayas is directly followed by a wave of high pressure that progresses from the western hills toward the east, accompanied by a cool northwest wind.

5. The conclusion that seems to follow is that an unusual extension of the snow-covering in the Northwest Himalaya acts upon the higher levels in summer like the ordinary fall of snow and rain in the lower regions of the Himalayas in the winter time, and favors the formation of the dry northwest winds on the plain of Western India.

6. That the dependence of the dry winds upon the Himalaya snowfall offers a criterion for the prediction of the probability of a drought in Northwestern and Western India. (*Z. O. G. M.*, XIX, p. 378, and *Nature*, XXX, p. 46.)

225. H. F. Blanford, in studying the theory of the winter rains in Northern India, concludes that the aqueous vapor evaporated from the earth's surface diffuses gradually upwards in the quiet atmosphere of Northern India and reaches an altitude favoring the condensation into cloud. When once in this way a moderately thick bank of cloud has

been formed, the equilibrium is soon disturbed, the diminution of temperature under the cloud is slower and the average temperature therefore higher. This suffices to inaugurate an inflow of air from all sides and an ascending motion and a falling barometer. Warm, moist air blows up from the south and we have the conditions for the winter rains. If this is correct we must consider the quiet calm air as the initial condition, but this calm is due to the existence of the high chain of mountains that surrounds Northern India on the east, north, and west. Were these absent the strong, dry northeast winds would carry away the vapor and the weather would be similar to that of Southern China.

226. [This is also a very fair description of the growth of a storm-center in the region west of the Mississippi, such as occasionally takes place directly under the observation of the Signal Office.] (*Z. O. G. M.*, XIX, p. 452.)

227. A. Richter, of Ebersdorf, has discussed the observations made at that place for six years on the direction of movement of the upper clouds, with the following results: The mean direction of the movement is from the point south 84° W., but for observations made one or more days before rain the direction is from a more northerly point, and for observations made a few hours before rain the direction is from a more southerly point. The probability of rain within twenty-four hours is greatest (65 per cent.) when the clouds move from the southwest; the general probability that rain will follow within twenty four hours after an observed cirrus is 56 per cent.; but rain fell on 58 per cent. of all the days in these six years; therefore, in general, the cirrus precedes non-rainy weather. This is explained by the fact that cirrus observations cannot be made when low clouds obscure the heavens, on which days the probability of rain is greatest. The direction of cirrus movement is for winter from the N. 82° W., and for summer S. 74° W. Using the wind direction as observed at a more favorable station five miles distant, it is found that the cirrus deviates from the wind most frequently by angles of plus or minus 45°, but the probability of rain is less when the wind is opposed to the cirrus than when the directions agree, and similar results are found by comparing the cirrus and lower clouds. On special days of low barometer the direction of the cirrus has no apparent influence upon the rainfall, but when the barometer is simply falling with a southwest wind the occurrence of cirrus movements nearly coinciding with that of the wind is in 73 per cent. of such cases followed by rain, while with northeast winds only 43 per cent. are followed by rain. (*D. M. Z.*, I, p. 319.)

228. Prof. H. Klein proposes to make more use than hitherto of observations of the cirrus clouds for purposes of weather prediction. The difficulty lies mostly in the fact that all observations must be made at the earth's surface, and we therefore know but little of their altitude and thickness. Systematic observations, however, have lately been made both by himself at Cologne and by Neumeyer at Hamburg, from

which he indicates a few rules additional to the ideas previously published by others. Thus he states that when a thin cirrus arc appears upon the western horizon with its summit in the west, this surrounds a depression still further west moving eastward, and will be followed in four to eight hours by a heavy rain. Again, if for twelve hours the cirrus clouds moving from the west occupy only the southern horizon, then for the next day we expect an east wind; but if the cirrus move from the southeast many dry days of east winds are to be expected, and if the cirri move from the east-northeast, or the east, a continuous dry weather may be expected.

229. [The importance of studying the movements of both upper and lower clouds which had already been abundantly indicated by Espy and Redfield and others, led the present writer to include all of these in his daily telegraphic dispatches for the Daily Weather Bulletin of the Cincinnati Observatory, the publication of which began in September, 1869. The daily manuscript weather map of the Army Signal Office began in 1871 to show the direction and kind of clouds, and the utilization of cirrus and other cloud movements for the anticipation of storms, and even as a first indication of the formation of a new storm-center, growing up immediately under one's eyes, became a matter of daily practice from that time.] (*Z. O. G. M.*, XVIII, p. 220.)

230. J. Damian, of Innspruck, by careful observations of the clouds during June, 1882, has endeavored to determine the relation between the rainfall and the upper and lower currents of air. He finds the quantity of rain greatest when the lower current is from the southwest and the upper current from the north, but least when the lower current is from the north with the upper from the south. When the angular deviation between the direction of the two currents is 23° he finds one case with rain and six without rain; when it is 45° the numbers are 1 and 9, respectively; when it is 90° the numbers are 2 and 8; for 135° the numbers are 8 and 3; for 180°, 4 and 1, which results are equivalent to saying that the more nearly the upper are opposed to each other the more likely is rain to follow. (*Z. O. G. M.*, XVIII, p. 345.)

231. G. Mantel gives in the Swiss *Annuaire* for 1882 a study into the connection between the number of clear and cloudy days in any period and the mean cloudiness of that period. His investigation is partly mathematical and partly based on actual observations. He shows that assuming a mean daily cloudiness of 1 on a scale of 10 for the clear days, 9 for the cloudy days, and 5 for the remaining days, we can compute the mean cloudiness even for a period of months in close agreement with direct daily observation. (*Z. O. G. M.*, XIX, p. 346.)

232. Grossman has studied the connection between the mean cloudiness of any period and the number of clear and cloudy days, in a manner similar to the study of G. Mantel for Switzerland. Grossman has tested Mantel's Swiss formula by application to the German stations; he finds that the monthly mean cloudiness (C) can be expressed as a

function of the difference between the number of cloudy and clear days by the formula $C=53+\frac{45}{n}(\text{cloudy-clear})$, where n is the whole number of days in the period. He, however, does not recommend that we give up computing mean cloudiness by taking the actual average of each day's actual observation. (*D. M. Z.*, I, p. 341.)

233. Roscoe and Stewart publish the results of observations made at Kew, 1875–'82 on solar radiation or the heat of sunshine as registered by Campbell's sunshine recorder; the original form of this apparatus consists of a wooden block with a hemispherical depression into which is inserted a spherical lens so that the focus of the lens lies at the surface of the wood, and it is assumed that the sun's rays char or burn the block in proportion to their intensity and duration. One block lasts from June 21 to December 21, and is then changed for a second block to last from December 21 to June 21. Twenty-four years of observations seem to show that the quantity of solar heat received by the block is greater from December to June than from June to December (due to cloudy weather?); there is also a slight trace of a double variation inside of each sun-spot period. (*Z. O. G. M.*, XIX, p. 546.)

234. Prof. J. M. Pernter has made a collection of data relative to the amount of sunshine received at different places on the northern hemisphere, and the few stations given by him serve to increase the interest in this important climatic and meteorologic element. His tables give the hourly and monthly averages and totals of the amount of sunshine recorded by the Beck-Campbell sunshine register for five stations in Europe, one in Asia, and four in Canada, all for the year 1882. [Records have been maintained for a number of years with this instrument at Washington, but have not yet been reduced and published. In fact some doubt seems to have arisen as to the value of these records.] Pernter expresses the wish that the publication of the results of the sunshine-register should be given by hours and tenths of hours, not the hourly means expressed as rates per day, and not the monthly means, but the hourly totals and the monthly totals. From his examination of the records it seems that the depression in the curve of daily rate that had already been established for Vienna at about noon appears with few exceptions at all other stations. St. Petersburg and Winnipeg, like Vienna, show in summer more sunshine in the morning than in the afternoon, and the reverse in winter; all stations have more sunshine in the afternoon than morning throughout the year; this peculiarity Pernter attributes to the difference between continental and marine climates.

By making use of Schott's tables of sunrise and sunset on account of their accuracy, Pernter computes the percentage of the observed to the greatest possible duration of sunshine. In general the annual totals and the annual percentages diminish with the increase of latitude; the annual averages are 61 per cent. for Bola, 46 for Toronto, 37 for Magdeburg, 47 for Winnipeg, 42 for Vienna, 41 for Sydney, 71 for Alla-

habad, 39 for St. Petersburg, 27 for Stonyhurst. In general there is a larger per cent. of sunshine in summer than in winter, or the short winter days have more cloudiness than the long summer days; but Allahabad shows the opposite, since there the months of longest days are the rainy months, and the highest percentages of sunshine occur in December and October. (*Z. O. G. M.*, XIX, p. 326.)

VII.—(*a*) WINDS AND OCEAN CURRENTS; (*b*) DYNAMIC LAWS FOR MOVEMENT OF AIR, CONSIDERING THE ROTATION OF THE EARTH AND THE LAWS OF THERMODYNAMICS.

235. Dr. Woeikof has calculated for fifty stations in Siberia and Russia the diurnal period in the velocity of the wind, and shows its intimate connection with the diurnal change of temperature and the uprising currents as explained by Köppen. Where the surface-heating is slight the diurnal amplitude is slight. (*Nature*, XXVIII, p. 571.)

236. The United States National Academy of Sciences has published a report of its expedition to Caroline Island, in the South Pacific, for the observation of the solar eclipse of May 6, 1883. The meteorological results obtained by Prof. W. Upton give, among other things, a new value of the atmospheric "constant of absorption of solar heat" and an approximate determination of the heat reflected from our atmosphere during totality; also a determination of the diurnal period in the force of the wind deduced from hourly records of the velocity of the sailing vessel as determined by the ship's log. During an interval of about ten days the vessel sailed in a uniform trade-wind without a single change in the trimming of the sails. Upton's results show a greater velocity of wind by night than by day.

237. [This exceptional result, if no flaw be discovered in the method, may possibly be explained (1) as due to the fact that the height of the center of wind-pressure against the sail is about 40 feet above the sea, and (2) by the assumption that above this elevation the wind has its normal velocity at night, but a less velocity by day, owing to the uprising of slowly-moving heated currents from the surface of the sea; in other words, the diurnal periodicity of the wind, which over the land is observed up to a height of many hundred and sometimes of several thousand feet, is over the sea felt up to the height of only a few hundred feet. Above that level its velocity is uniform; immediately below it the velocity is least in the middle of the day, while at the surface of the sea the velocity is greatest in the middle of the day. The Espy-Köppen theory has not yet been developed far enough to enable us to state the relation between temperature of earth or sea surface, and the height of the plane of no diurnal wind-period, but it is evident that the height over the sea may really be as small as Upton's observations indicate. This result explains also the peculiarities of the diurnal land and sea breezes at sea-shore stations when the general winds are from land or water.]

238. H. E. Hamberg, of Stockholm, has published a third memoir on the diurnal variation of the force of the wind. The author endeavors to show that the amplitude between the daily maximum and minimum of wind velocity is greater for strong winds than for feeble ones. As to the questions whether the amplitude of the wind is best expressed by the difference between the maximum and minimum or by the ratio between them, Hamberg is of the opinion that the ratio should be preferred, but Hann remarks that the question can only be decided after considering the object of the investigation. After discussing this question, which is again fully replied to by Hann, Hamberg communicates the results of a large collection of data elucidating the diurnal changes for all classes of winds and for numerous stations in Europe; he then passes especially to the daily period for Upsala in the winter time, showing that the amplitude increases with the strength of the wind, and that the influence of cloudiness is but slight. (*Z. O. G. M.*, XIX, p. 303.)

239. E. Stelling discusses the wind direction in the lower portion of the rivers Obi and Jenissei. He shows that the southeast, south, and southwest winds of North and West Siberia do not belong to any North Atlantic cyclonic system, but belong to the anti-cyclonic winds attending the high barometer of Northern Asia. (*Z. O. G. M.*, XIX, p. 417.)

240. Prof. H. Fritz shows that the whisper wind, which is a local current at the entrance of the narrow valley of the Rhine, blowing down the upper portion of this valley in the evening and early mornings of warm, clear days, is simply a part of the general current of air in the valley of the river, and not to be attributed to any special influence of the Wisperthal which is popularly and romantically associated with the wind. (*Z. O. G. M.*, XIX, p. 246.)

241. J. M. Pernter, in a second contribution on the winds at high altitudes, shows that on the summit of the Obir the southeast and south winds are most frequent, and therefore the upper trade or return trade has no existence there. For both frequency and total movement there is a double maximum and minimum. The diurnal wind-changes follow the sun, namely, they veer with the sun during the day time, but during the night time "back" or return against the sun. The north and northwest winds are the strongest, the south and southwest the softest. By selecting fifty-one perfectly clear days the daily period becomes still more pronounced, confirming the author in his supposition that the sun's heat is the principal cause of the diurnal change of wind force. (*Z. O. G. M.*, XIX, p. 380.)

242. R. Billwiller, of Zurich, has published a preliminary discussion of the results of the anemometer records for August, 1883, with the Munro anemograph on the summit of the Säntis. He fears that the instrument will not work satisfactorily in the winter, owing to the frost and ice that accumulate during the prevailing moist west winds, and has attempted therefore to make a comparison during the favorable weather with the records of the observatory at Berne, which is situated in an

open, free space, and fairly represents the wind of the northern base of the Alps. In general he finds for Berne the southwest and north to be the most frequent winds, while for Säntis they are the southwest and west. The total movement of the wind is, for Berne 2,500, but for the Säntis 22,000 kilometers during the month. The strongest winds for Berne are southwest, north, and northeast, but for the Säntis southwest and west. The altitudes for the two stations are, for Berne, 570 meters; for the Säntis anemometer, 2,508 meters, the anemometer cups being 4 meters above the summit of the mountain. The diurnal velocity of the wind is very great at Berne, having a maximum velocity of 10.0 kilometers per hour between 1 and 2 P. M., and a minimum of 0.1 between 4 and 5 A. M., but for the Säntis summit we have a maximum 38.1 between 3 and 4 A. M., and a minimum 28.2 between 8 and 10 A. M., and again between 2 and 3 P. M. (*Z. O. G. M.*, XVIII, p. 416.)

243. The first year of observations on the summit of the Säntis (altitude 2,467 meters) are published by Hann, from which we see that the greatest wind velocity occurred at 9 P. M. on the average of the year, the mean value being 1.60 of the scale on the Wild tablet anemometer, the maximum being 2.2 in March and the minimum 1.2 in June; the average lowest wind force was 4.10 at 1 P. M., the highest being 2.1 in November and the minimum being 0.8 in June. (*Z. O. G. M.*, XVIII, p. 479.)

244. Stevenson has from some observations at heights less than 200 feet endeavored to obtain the rate of increase of the wind with the altitude. He finds that the following formulæ represent his observations:

For wind velocity $\frac{v}{V}=\sqrt{\frac{h}{H}}$; wind pressure $\frac{f}{F}=\frac{h}{H}$

where the small letters refer to the lower station and the large letters to the higher; the velocities are expressed in miles per hour, the pressures in pounds per square foot, and the altitudes in feet. By means of these formulæ it should become possible for meteorologists to reduce all observed wind velocities and pressures to a uniform standard altitude.

245. [It would seem that one of the most important steps to be taken in the near future, in order to render the study of daily weather maps a more precise scientific matter, consists in the correction of anemometer readings for instrumental and local peculiarities and their reduction to a uniform altitude above the surface of the ground; similarly the temperature and moisture observations so far as they relate to the moving mass of air should be reduced to a uniform elevation; as regards rainfall the correction for local and instrumental peculiarities seems almost hopeless, but is none the less desirable; the reduction to a uniform altitude, however, is a much simpler matter.] (*Z. O. G. M.*, XVIII, p. 319.)

246. E. D. Archibald, of London, has undertaken an investigation into the velocity of the wind as affected by the altitude above ground, and has extended Mr. Stevenson's experiments (which terminated with a

height of 50 feet), by means of kites extending up to 1,500 or 2,000. For the formula $\frac{V}{v}=\frac{H}{h}$ given by Stevenson, which should not be used above 100 feet, Mr. Archibald suggests the following: $\frac{V}{v}=4\sqrt{\frac{H}{h}}$ which is one of Stevenson's first formulæ. This holds good up to 23,000 feet if we may rely upon the observations of Vettin, and does not vary very much from the formula given by Ferrel, viz:

$$p=\frac{0.0027}{1\times 0.003665t}\frac{P}{P'}v^2$$

(*Nature*, XXVII, pp. 243–507.)

247. Mr. Thomas Stevenson, of Edinburgh, replies to Mr. Archibald's remarks and maintains that his own second formula is abundantly sufficient to represent the observed increase of wind-velocity. (*Nature*, XXVII, p. 432.)

248. A. Buchan communicates the results of the Challenger observations as to the diurnal velocity of the wind on the open sea near the shore and on land. These results are also incorporated in his article on Meteorology in the Encyclopædia Britannica. (*Nature*, XXVII, p. 413.)

249. Mr. E. D. Archibald differs from Buchan in the latter's explanation of the diurnal variation in the variation of the wind, and affirms his adherence to the views of Espy and Köppen. (*Nature*, XXVII, p. 461.)

250. W. Köppen criticises some passages in Hann's Climatology relative to land and sea breezes, and his remarks suggest the importance of a few additional observations in favorable localities; thus he says the origin of the sea breeze is not primarily due to the increase of pressure in the upper part of a warming column of air. Since the sea breeze begins over the sea and subsequently stretches to the land and up into the bays and inlets, this must be attributed to the resistance of the land retarding the breeze which is felt at a little distance out over the sea and is first overcome when the pressure increases to a certain limit.

Köppen thinks that since the sum total of the upper and lower circulation is certainly stronger by day than by night, and as the land breeze is feebler than the sea breeze, it is not necessary to conclude that a land wind is blowing strongly at some altitude above the earth's surface. He calls attention to the fact that although the sea breeze is generally intensified when the prevailing wind direction agrees with it, yet, on the other hand, observation does not confirm the idea that the land wind is increased when the prevailing winds agree with it. This reversion of the preceding law is an apparently natural one, and is, perhaps, generally supposed to be true, but, as Köppen remarks, actual observations do not confirm it, and we evidently still need a correct explanation of the mechanism of the sea breeze. (*Z. O. G. M.*, XIX, p. 39.)

251. [Is not this explanation suggested by the above note on the results of Professor Upton's study of a ship's velocity in the South Pacific Ocean, *i. e.*, the level of uniform maximum velocity is much lower over

the sea than over the land, owing to the feeble uprising current, as it is also lower over the slightly heated lands of high latitudes and over the land during the night as compared with the day time.]

252. Dr. A. Sprung, of Hamburg, in reference to the daily period in the direction of the wind which has for centuries been recognized, says that the theory of vertical ascending currents or topsy turvey movements would lead us to the following conclusions which are fully explanatory of this periodicity:

1. In the northern hemisphere, on the low plains and on high plains, the wind has a tendency to change its direction with the hands of a watch in the morning and against the hands in the afternoon.

2. In the northern hemisphere on the summits of mountains a similar oscillation in the direction of the wind will occur, but in the opposite direction.

3. In the southern hemisphere the oscillation at low stations will be against the hands of a watch in the morning and with them in the afternoon, or opposed to the rule for the low lands, and agreeing with the rule for the mountain summits in the northern hemisphere.

4. In the southern hemisphere for mountain summits the oscillation is opposite to that of the low lands of that hemisphere.

5. At the equator the wind direction is not affected.

6. On the ocean, where the daily period in the strength of the wind is slight in consequence both of the slight vertical diminution of friction and of the slight warming of the ocean surface, this oscillation in direction is also not sensible.

So far as observations are at hand the above conclusions seem to be confirmed, and so strong is the deflection due to uprising currents thus theoretically explained that the diurnal change of wind at most northern stations consequent on the eastward movement of storm-centers whose paths lie north of the station is almost entirely annulled by it in the afternoon, whereas in the morning the two forces combine to exaggerate the phenomenon. (*D. M. Z.*, I, pp. 15–65.)

253. Dr. A. Sprung gives an elementary geometrical derivation, which is more complete than that given by Zöppritz and Buff, of the deflection due to the earth's rotation. (*D. M. Z.*, I, p. 250.)

254. Wm. M. Davis, of Harvard College, gives an elementary proof of the deflection, due to the earth's rotation, of bodies moving parallel to its surface, showing the three general principles upon which, he says, Professor Ferrel bases his formula for this deflecting force; this is reproduced by Hann with a few notes from Van Nostrand's Engineering Magazine. (*Z. O. G. M.*, XVIII, p. 299.)

255. Dr. F. Roth, of Buxtehude, comments upon Professor Davis' presentation of the subject to the effect that it does not make clear the point under dispute between himself and Dr. Sprung; he, however, recognizes that Professor Davis's method of demonstration virtually assumes that the earth is a sphere, and that the true or apparent force

of gravity is perpendicular to the surface of a sphere. He prefers himself, however, to consider the earth as a spheroid formed by the rotation of a fluid mass, and to assume that the direction of the plumb-line is always towards the center of the spheroid; this he thinks corresponds better to the practical taste of the American, and is about the same as Professor Ferrel has adopted. He then shows that of the three components into which Professor Davis analyzes the deviating force of the earth's rotation, only the first actually exists. (*Z. O. G. M.*, XVIII, p. 376.)

256. H. Bruns, of Leipsic, in reference to the movement of the atmosphere over the earth's surface, states that Roth and other authors have generally assumed the earth's surface as perfectly smooth; he, therefore, gives the formulæ required when we introduce the consideration of friction, and shows that assuming the earth to be a surface of rotation the friction will not affect the azimuthal deviation known as Ferrel's law. (*Z. O. G. M.*, XVIII, p. 425.)

257. F. Roth, under date of October, 1883, communicates a note on the deviations of motions of the earth's surface, in which he shows that the angle that determines the direction of motion as affected by the earth's rotation varies only with the time and is entirely independent of the kind of frictional resistance; it is the same for any force that acts in the direction of the path, and holds good for locomotives, steamships, moving animals, &c. If the frictional resistance is in direct proportion to the velocity, but in other respects the moving body is impelled by its own inertia, then the orbit is a spiral turning with the sun and can be expressed by the following equation:

$$r = r_0 \, e \, \frac{a \, \theta}{2 \, w \sin \varphi}.$$

We therefore arrive at a remarkable confirmation of the assumption with which Guldberg and Mohn commence their investigations. (*Z. O. G. M.*, XIX, p. 41.)

258. F. Roth, in reference to his development of the path of moving bodies on the earth's surface, controverts the position taken by Professor Bruns to the effect that theoretical and mathematical investigations have but little practical interest for the progress of meteorology unless every detail is considered instead of the approximate solutions frequently given; the fact, however, is that Bruns' effort to introduce the consideration of friction can scarcely be called very successful, as he certainly has made no greater progress than did Finger in his memoir of 1877. However, Roth finds in Bruns' work a confirmation of the correctness of his own previous assumption, namely, that the earth is a sphere to whose surface the observed force of gravity is perpendicular. Taking complete account of the side forces introduced by frictional resistance, Roth shows that it is not immaterial in which direction a body moves on the earth's surface, but that the deviating force is for a motion towards the east greater than one towards the west. He gives also the

formula for the change in the velocity due to friction, in which respect he agrees with Professor Bruns. As has been before stated, the orbit of a free particle moving on a horizontal plane under the influence of the earth's rotation and its own friction (assumed to be directly proportional to the velocity) will be a logarithmic spiral. If, however, the friction depends upon the square of the velocity, then the differential curve is easily given, but the integrated equation involves a series of sines and cosines. (*Z. O. G. M.*, XIX, p. 523.)

259. Prof. L. de Marchi, of Rome, has published in the Annals of the Rome Meteorological Office an investigation into the mathematical theory of the winds, in reference to which Dr. M. Margueles gives a review with criticisms. Marchi aims to show that the quantity which in hydrodynamics has been known as Wirbelgeschwindigkeit has an important meaning in the mathematical theory of the winds. If we indicate this quantity by ζ, then the total rotation of any particle of air is equal to ζ plus the rotation of the earth, and the total rotation is always positive or against the rotation of the sun; the lines of equal total rotation are also curves of equal density; that any condition in which the quantity ζ is zero cannot long exist over a large surface. If we assume that the total rotation of a particle of air is constant for its whole orbit, which Marchi thinks rendered probable by actual observations, but which Dr. Margueles thinks wholly arbitrary, then it follows that the density is greater where ζ is greater. If a region where ζ is zero divides two regions of positive and negative values of ζ, then the density of the air will increase towards the positive and diminish towards the negative ζ; he thus explains the distribution of pressure in cyclones and anti-cyclones, and for the special case that the orbits of the particles of air are logarithmic spirals the total rotation is constant throughout the whole horizontal movement. Assuming the Mohn and Guldberg relation between density and temperature, Marchi finds that when in the center of a cyclone ζ is negative, this is then a warm center, but when ζ is positive it is a cold center, provided that in both cases the curve of $\zeta=0$ completely incloses the center. After going into many details in relation to individual simple cyclones, the author remarks that by drawing lines for equal values of ζ, especially $\zeta=0$, we can easily study the ordinary complicated combinations of the daily weather map. He lays it down as a general rule that two lines of equal values of ζ can never intersect each other, and that a line of uniform ζ must either be completely inclosed or must extend to the very limits of the fluid; he proves that if the line is closed, then the dilatation due to the motion will be greater on the north side than on the south side, thus explaining the tendency of cyclones to move towards the pole and of anti-cyclones towards the center in a different manner from that given by Ferrel. (*Z. O. G. M.*, XIX, p. 278.)

260. In explanation of the above assumption to which Dr. Margueles objects, Professor Marchi states that he did not enunciate this as a

general proposition, but distinctly as a special hypothesis appropriate to a number of practical examples, and that in general such restricted hypothetical cases must first be solved before we can, in the present state of our knowledge, proceed to the general solutions which are now impossible. (*Z. O. G. M.*, XIX, p. 480.)

261. Prof. A. Oberbeck, commenting upon the memoir of Marchi, states that his own investigations have led him to a different conclusion. In the first place the expression Wirbelgeschwindigkeit (which is not used by Helmholtz) is not properly applied to the movements represented by Marchi by the letter ζ; in the second place the conclusion that ζ cannot be zero for any length of time over a large space is incorrect; in general the formula for the motion of the air as given by Guldberg and Mohn is at present the best for comparison with the observations; and if the latest researches of hydrodynamics are to be considered, this can best be done by the formulæ given by Oberbeck in Wiedemann's Annalen for 1882. (*Z. O. G. M.*, XIX, p. 489.)

262. Miller-Hauenfels in his Theoretical Meteorology endeavors to deduce philosophically from fundamental principles of mechanics and physics all the principal phenomena of the atmosphere. He first shows that the density of the atmosphere from the poles towards the equator diminishes more rapidly than has heretofore been supposed. Since the unequal warming of the strata of air disturbs the equilibrium it becomes the office of the winds to endeavor to restore this normal density. By studying the isosteres, or lines of equal density of the air, he finds simplified laws for the wind movement, based on the principle of continuity.

The trade-winds girdling the earth can send no equatorial currents toward the pole, but constitute a circulation of their own on both sides of the equator. The author shows considerable dexterity in unraveling the complicated phenomena, and his work is worthy the study of mathematical and physical meteorologists. (*Z. O. G. M.*, XVIII, p. 483.)

263. Dr. Vettin, of Berlin, according to Köppen, more than 25 years ago published in volume 102 of Poggendorf's Annalen the results of his experiments on movements in the atmosphere. These experiments, together with his equally long-continued observations upon the clouds, form an invaluable contribution to our knowledge of aerodynamics, affording, as they do, abundant opportunity for testing mathematical theories. A number of these experiments are described by Vettin in the Journal of the German Meteorological Society, and will, it is hoped, lead to the complete publication of his work, as he seems to be able to reproduce nearly all the phenomena of storms. (*D. M. Z.*, I, p. 227.)

264. Prof. Osborne Reynolds has communicated to the Royal Society of London an experimental investigation into the motion of water, which, from its comprehensiveness, constitutes an important contribution to our knowledge of hydrodynamics; the innumerable ingenious experiments, the empirical formulæ and curves, and the comparison with deductive or theoretical formulæ mark an advance in our knowledge that

will find many applications in the atmospheric movements. (*Nature*, XXIII, p. 627.)

265. An anonymous article in *Nature* expresses some views on the upper currents of the atmosphere, and suggests certain lines of research into some of the more striking optical phenomena. [So far as the dynamic problems are concerned there seems a little confusion as to the cause.] (*Nature*, XXIX, p. 154.)

266. Dr. H. Hertz, of Kiel, presents an elaborate and important convenient graphic method for determining the changes in the adiabatic condition of moist air. [The translation of this in full will, it is hoped, be published for the benefit of American students.] The author states that the condition of moist air, after being compressed or expanded without addition of heat, has to be considered daily by the meteorologist; he desires therefore to offer to the student the means of solving the various questions without recourse to complicated formulæ. At present it is customary to use the little table published by Professor Hann in 1874, but he thinks that we can achieve more complete solutions with equal ease by employing the graphic methods and the engraved table of curved lines that he has prepared. He proposes nothing especially new in addition to the publications of Hann, Guldberg, and Mohn, but accomplishes the equally important result of making their formulæ easily available in daily use. (*D. M. Z.*, I, p. 421.)

VIII.—Barometric pressure and its variations.

267. A. M. Pearson, of Bombay, compares the barometric changes of monthly means at Zanzibar, Belgaum, and Bombay for three years, and shows there are evidences of the movement of barometric waves eastward through these stations, the time of transit being 4.9 months from Zanzibar to Bombay, with numerous smaller coincident deflections. He very properly claims that the atmosphere must have vibrations and waves originating in various ways, of which these barometric phenomena are the results. Similar studies, by J. Allan Broun, have lately been published by the Manchester Philosophical Society. (*Nature*, XXVIII, pp. 354–377.)

268. In a note of September 4, 1883, Mr. Pearson affirms that the atmospheric waves have been traced regularly since 1869; and that the reason why they have a movement in tropical and sub-tropical regions westward more rapid than eastward is owing to their combination with the westward movement of the air in those latitudes, but as to the reason why the amplitude is greater at eastward stations he advances the hypothesis that the westward component proceeds from the tropics, where all great movements originate. (*Nature*, XXVIII, p. 562.)

269. A. Schomrock, of St. Petersburg, has compared the occurrence of small, sudden, irregular variations of atmospheric pressure as recorded on the barographs at St. Petersburg and Pavlosk. These have an annual periodicity, being most frequent in November, December, July, and

January, and somewhat less so in June and February. Sometimes they continue only for a few hours, occasionally even only one occurs, but frequently they follow each other in an uninterrupted series for many days. Occasionally they attain an amplitude of many millimeters; they occur both with rising and falling pressure, both during a maximum and minimum, but most frequently during the latter, and least frequently during the maximum. They have an undeniable connection with precipitation, so that whenever they occur there is, in most cases, simultaneously either rain, snow, or fog, or the formation of clouds, but inversely they are not an invariable accompaniment of such phenomena; they do not appear to depend on the direction or strength of the wind. They have a most interesting and undeniable connection with thunder-storms, being, with very few exceptions, invariably to be observed, so that one may determine the time and duration of a thunder-storm by these irregularities of pressure. In order to ascertain how general or local these perturbations are, Schönrock compares the records at Pavlosk and St. Petersburg and finds that they occur together at both places, but the character of the records made by the Wild barograph, namely, one record every ten minutes, conceals very many of the details and renders the comparison very unsatisfactory. (*Z. O. G. M.*, XIX, p. 396.)

270. [Schönrock has here initiated a study which must have long claimed especial interest on the part of every one who has had access to the records of a self-registering barometer. Of the barographs at present in existence, one of the most sensitive instruments and one well adapted to this class of investigations is that invented and constructed by Hough and established at Albany, at the Dudley Observatory, the hourly readings of which have been quite fully published and discussed by him. A duplicate of this instrument was set up at the Army Signal Office in Washington in 1871, and still continues to perform satisfactorily. Several others have been constructed introducing modifications of Hough's construction, so that abundant opportunity has been offered during the past fifteen years for studying, on a continuous and very perspicuous register, the occurrence of these irregular and rather mysterious changes of pressure. We have been accustomed to consider that these may be produced by either one or all of the following causes:

1. Sudden gusts of wind blowing across chimney tops produce drafts and lower pressures, or blowing into the window of an otherwise closed room produce slight increase of pressures within the room where the barometer is placed.

2. The downfall of rain, cooling and dragging with it air, pushes out from the region of rainfall as a gust of wind; this gust, as it pushes against surrounding resisting masses of air, is compressed, whence a temporary increase of pressure results in the locality preceding the advancing rainfall, precisely as has been explained by Espy, Henry, Köppen, and others.

3. Every ascending mass of air must be accompanied by the descent

of other masses, and these latter may so descend bodily and rapidly to the earth as by their inertia to experience a slight compression on reaching the earth's surface. This is perhaps best seen during the clear or partly cloudy weather that accompanies our west winds. These winds blow in gusts, the velocity at any one station alternating between 0 and 5 to 15 miles per hour. An observer standing on an open free space may generally easily recognize the fact that when such a gust is blowing dust and leaves violently towards him, there is a little way beyond a simultaneous wind blowing dust in the opposite direction, and by careful circumspection he will assure himself that a downrush of air over a well-defined circular region is being followed by its being pushed out in all directions, thereby constituting the gust as observed by him. This downrush of air may plausibly be supposed to be due to the fact that at a short distance above a quantity of colder or drier and denser air was ready to come down whenever the hot air below came to a state of unstable equilibrium. The stoppage of any such downrush gives rise to a temporary compression and increase of pressure which usually lasts for short spaces of time, a half minute or more, but when great cumulus clouds pass by this may continue for five minutes.]

271. An interesting example of such barometric changes is given by the Vienna Meteorological Institute as occurring on the 18th of October, 1884. The Kreil barograph (continuous register) shows that from noon of the 17th to 7.25 A. M. of the 18th pressure fell steadily, then remained constant for five minutes, and at 7.30 A. M., entirely unannounced, jumped up 2.3^{mm}, and continued ascending steadily until noon. The Theorell barograph (recording every fifteen minutes) shows an increase of 2.7^{mm} between 7.30 and 7.45 A. M. The Hipp barograph (registering every ten minutes) shows a similar jump between 7.20 and 7.40 A. M. The following were the attending meteorological phenomena: A heavy northwest storm prevailed during the night of the 17th and 18th, diminishing somewhat in the morning; at 7.30 A. M. the wind suddenly sprang up from the north, it grew dark, and a heavy rain shower from the north occurred, the total rainfall being 16^{mm}, of which 6.3^{mm} fell in the first ten minutes; after this shift in direction the force of the wind diminished, the temperature sank, and the storm died away.

As this sudden barometric change corresponds to a sudden increase of pressure to the amount of 36 kilograms on the human body it is a subject that may interest physicians as well as meteorologists. (*Z. O. G. M*, XIX, p. 236.)

272. E. Renou, of Paris, has published an exhaustive and most careful study of the records of barometric pressure at Paris. These records begin in 1689, but only in 1809 does the instrumental temperature begin to be given, and only since1834 is the series commensurable in accuracy with those of the present day. Assuming that the average pressure has remained the same, he corrects the older series of observations,

and, among other conclusions, he shows that for Paris we cannot safely assume that the mean pressure in winter must be higher than in summer, as many years show the opposite condition. (*Z. O. G. M.*, XIX, p. 541.)

273. Mr. H. F. Blanford and Mr. Hill have published contributions to the daily periodicity of the barometric pressure in India. The observations at Goalpara, Patna, Leh, and Allahabad have been especially studied by them. In general it may be noted that the daily change of pressure is in the valleys of the warm zone characterized by an early occurrence of the morning maximum. The daily amplitude is 0.0048 of the mean daily pressure, or about 0.14 of an inch. (*Z. O. G. M.*, XVII, p. 258.)

274. Prof. H. Mohn has published the volume containing the results of the Norwegian North Atlantic expeditions, 1876 to 1878, in which he contributes the first observations that we have of the daily periodicity of meteorological phenomena in this important region of the North Sea. With regard to the pressure, we have a scarcely perceptible minimum between 8 and 9 P. M., a principal minimum at 4 A. M., and a principal maximum at 2 P. M. Combining this with the results of the Challenger expedition it seems likely that there is no evening minimum under normal conditions in this region; so that on the open sea in high latitudes in both North and South Atlantic only one minimum and one maximum appears in the diurnal curve of pressure. (*Z. O. G. M.*, XVIII, p. 470.)

275. J. M. Pernter contributes to the subject of daily and annual variations of pressure on mountains and in valleys a short study of some observations in Austria, Switzerland, and on Mount Ararat. He finds the following results for mountain peaks:

1. The curve of daily change is flatter for the elevated stations, the morning minimum diminishes, while the afternoon minimum grows flatter, but without disappearing, as it is still very prominent upon Mount Ararat; up to a moderate height the daily amplitude diminishes, but then begins again to increase.

2. The evening maximum, that is quite small in low, flat lands, increases with the altitude until it finally becomes the principal maximum of the day. This has been known in a few instances, and ascribed to special local circumstances, but is now recognized as a general law of much import.

3. The periodicity during the day is not the same for summer and winter seasons: thus for a low peak in summer the mid-day maximum comes later than in winter, and this delay is greater in proportion to the altitude, amounting to two hours at the highest station.

With reference to valley stations, he finds a dearth of material in the higher Alpine valleys, but comes to the following conclusions:

4. The daily amplitudes are remarkably large.

5. The afternoon minimum is remarkably deep.

6. The time of afternoon minimum varies from 3 P. M. in winter to 5 P. M. in summer.

7. The morning minimum disappears or is very flat.

8. The morning maximum occurs very early—on the average at 8 A. M.; and the evening maximum, which is more pronounced than in open localities, is much delayed—even until 1 A. M.

With reference to the cause of the differences in diurnal periodicity between valley and mountain stations, he remarks only that the principal cause, as long since recognized, is the expansion and contraction with temperature of the stratum of air below the mountain, but that, besides this, dynamic causes contribute especially to the formation of the evening maximum. A further investigation will be given by him when he has secured two full years of all the observations at high and low stations. (*Z. O. G. M.*, XVIII., p. 290.)

276. [Many studies have contributed to show how slight is the diurnal change of temperature of the great mass of air, and we may therefore doubt whether the expansion and contraction corresponding to this slight diurnal temperature change suffice as a static explanation of the diurnal barometric differences at the top and bottom of a high mountain. We are rather inclined to think this a minor factor in the explanation of the phenomena to be studied by Pernter, and that he will find that some kinetic law covers the whole ground. The broadest basis for this explanation has been given in the investigations by Ferrel and others, and I have for many years taught that the phenomena, after allowing for a small static influence, are reducible to three dynamic causes: one general for the whole earth's surface; a second, special for the latitude and the continent; a third, and least important, special for the locality, its altitude and its immediate surroundings, including the exposure of the barometer to the influence of winds.]

277. André, of Paris, has studied the diurnal variation of the barometer at different altitudes above the sea, and confirmed the results recently announced by Hann, Pernter, and others. He also concludes the existence of a third maximum in the winter months, occurring about 2.30 P. M. (*Z. O. G. M.*, XIX, p. 143.)

278. Dr. R. Maurer publishes in full the results of hourly barometric observations for one year—April, 1883, to March, 1884—on the summit of the Säntis and the Great St. Bernard, and compares these with observations made at other high stations in the Alps. The mean gradient between the two stations is as follows: For the spring, 0.10; for the summer, 0.22; autumn, 0.69; winter, 1.10 millimeters. These figures give a new demonstration of Hann's conclusion, that only in winter in extra-tropical latitudes can great general gradients occur in the higher atmospheric strata, while in summer, with a much more uniform distribution of temperature, warmth, and moisture, the gradient is slighter. (*Z. O. G. M.*, XIX, p. 513.)

279. Prof. B. Busin, of Rome, suggests that we may derive advantage

from studying a system of lines similar to isobars and constructed in the following manner: If from the center of the earth radii are drawn through the ordinary elliptical isobars we have a system of cones, which can be so cut by a plane that the sections shall be concentric circles; if then we project this system upon the earth's surface, we have a system of circles to which may be directly applied the mechanical principles deduced by Ferrel, Colding, and others. He suggests it as his own belief that the physical reason why we should recur to such a system of central projection consists in the fact that the axes of the cyclones are ordinarily inclined to the earth's surface, as he has in fact satisfied himself by the study of the cyclones that pass over Sicily. (*Z. O. G. M.*, XIX, p. 454.)

280. Prof. Elias Loomis, in his nineteenth contribution to meteorology, (American Journal of Science for December, 1883), discusses the barometric gradient in great storms, and shows that the effect of friction is greater than as assumed by Ferrel in his formula. (*Nature*, XXIX, p. 252.)

281. In his twentieth contribution (American Journal for July, 1884), Professor Loomis especially discusses the reduction of barometric observations to sea-level; he concludes that the pressure coefficient in the hypsometric formula of Laplace is too small.

282. [As this conclusion is based on the assumption that the temperature of a mass of air below the mountain top is correctly given by taking the mean of the temperatures as ordinarily observed near the ground at top and bottom, which assumption is quite erroneous for the clear nights and days that prevail during high pressures, but more nearly correct for the cloudy weather and high winds that prevail during low pressures and storms, it would seem that systematic errors are hereby introduced that must affect his conclusions]

IX.—(*a*) General storms; (*b*) Local storms; (*c*) General weather relations.

283. Dr. W. Köppen has published charts of the frequency and mean paths of barometric minima between the Rocky Mountains and the Ural. His charts are based upon the recent work of European meteorologists, especially Hoffmeyer and Hageman, and upon the work of the Signal Office during 1873 to 1879, especially its international bulletin. [His frequency charts are similar to those compiled in 1874 by Abbe, and published by the United States Census Office, and those of Finley recently published by the Signal Office, while his charts of mean storm tracks are similar to those compiled by Lieutenant Jackson under the special orders of General Myer, in 1875.] Köppen has, however, greatly improved upon previous publications of this kind, not only in more careful collation of data, but especially in that for the first time he brought American and European storms together in sufficient number to show the general relations between them. He finds that the move-

ments and changes of depressions of storm-centers on the ocean are much more irregular than over the North American continent. The main storm track passes from Wisconsin eastward to Newfoundland, thence northeast to the North Cape; outside of this track, areas of great storm frequency are found in Davis Straits and Northern Germany. (*Z. O. G. M.*, XVII, p. 257.)

284. Dr. J. van Bebber has presented an admirable discussion of the relative position, velocity, and intensity of the barometric minima of Europe that have occurred during the years 1876 to 1880, inclusive. His statistics are presented in the shape of charts showing by curved lines the regions of equal mean velocity; equal maxima of barometric depressions; equal average barometric depression, and equal average barometric departure of the pressures at storm-centers from the normal pressure. He finds that the mean velocity of progress of a storm-center is greater in the United States than in Europe, it being 100 myriameters per day in the United States and only 64 myriameters in Europe. For both countries, however, the annual periodicity is about the same, showing a minimum in August and a maximum during the winter, which, as he says, is an important indication of the fact that some general causes regulate the movement of storm-centers throughout the world. The velocity of the most rapid storms exceeds 150 myriameters in thirty cases during the five years; the greatest number of cases of any one velocity is that of 40 to 50 myriameters, for which there were 217 cases. (*Z. O. G. M.*, XVII, p. 297.)

285. Leyst has made a study of the storm tracks in European Russia and Western Siberia for the years 1878–'80. He considers only the storms of such a nature as those for which storm signals should issue from the central office at St. Petersburg. Out of 250 cyclones there fall in summer 17 per cent., autumn 29, winter 30, and spring 24 per cent. The mean pressure of the central minima is for summer 738 millimeters, for October 732, and for November to March 727. The mean velocity increases as the storms move eastward, and in the summer time the central depression also increases. The velocity of progression is also greatest in January and least in July. The strongest gradients are for stations south and southwest of the centers, and the strongest winds themselves are directed towards the southwest in January, February, and June, but to the northwest in March and to the east-northeast in April. When the cyclone comes into such a position that Russia is in its southwest part, it has already moved further away from the high pressure of Southwest Europe, and also has grown weaker by its passage towards the north or northeast, and for both these reasons the storm in the southwestern quadrant of the cyclone diminishes. (*D. M. Z.*, I, 326.)

286. M. Möller, in some remarks on the cause of the movement of barometric depressions, says these depressions are columns of air of less weight than the surrounding masses of atmosphere; the movement of

the depressions results partly from renewed formation, partly from progression; both methods of movement can act in conjunction or in opposition. In reference to the movement of progression it can be analyzed into three causes: influence of the distribution of atmospheric pressure; influence of the mean distribution of temperature; influence of the earth's rotation. The first influence is treated of by Dr. Köppen (Z. O. G. M., February, 1880), who shows that the presence of a maximum pressure increases the lower winds and thereby increases the rapidity of movement of the depression. But Möller has also shown that the upper winds carry the depressions with them, so that the progressive movement of a depression is to be considered as a consequence of the movement of a thin layer of warm air and of the movement of a space of rarefied air due to the *vis-viva* of the forces in action. The third cause of movement, namely, the rotation of the earth, in all latitudes, causes a movement from east to west and also towards the nearest terrestrial pole. In this way he explains the western movements in the torrid zone, where he says this effect of the earth's rotation is at a maximum, while the other causes become efficacious in the middle and higher latitudes. [Möller's poleward tendency seems to be the same as that first pointed out by Ferrel in 1857, but to which we believe the latter now attaches less importance. The poleward tendency for the lower winds is balanced by the equatorial tendency due to the higher winds.] As regards the second cause, namely, the distribution of temperature on the earth, this is principally controlled by the sun's heat; and introducing the algebraic expression for this he shows that the combined influence of heat and rotation is to produce a motion towards the west within 30° of the equator, but toward the east, in more northern latitudes, up to a certain limit in the polar circle. The rather complicated formula given by him can be put in tabular form in such a way as to be conveniently used in a strictly scientific estimation of the most probable path that will be pursued by any depression.

287. [It is important that Möller's formulæ be applied to the study of the storms of the United States for the purpose of telling more exactly the value of the considerations that he has given. It cannot be doubted but that other more important physical laws, such as the condensation of moisture, the heating of the upper layer of clouds, the relation of continents, oceans, mountain ranges, plateaus, and lowlands have also so large an influence that the questions of inertia and temperature of the moving atmosphere have only a partial if not in fact a subsidiary interest.] (*Z. O. G. M.*, XIX, p. 274.)

288. R. H. Scott has discussed the question of the reality of the existence of so-called equinoctial storms in the British Islands. To this end he has examined statistics since April, 1870. It is evident from the tables he gives that they simply confirm the results of studies by Dove, Loomis, and others, namely, that no one day of the year is especially stormy, although the maximum number of storms in England increases

systematically from 0 in June and July up to 31 or 32 in December and January. (*Z. O. G. M.*, XIX, p. 393.)

289. Prof. M. Dechevrens has published a monograph on the typhoons of July and August, 1882, wherein he traces the history of the whole course of several typhoons along the coast of Asia. (*Nature*, XXX, p. 388.)

290. W. Köppen, in reference to the change with altitude of the position of the center or axis of lowest pressure, sums up his conclusions as follows: The center is at high altitudes pushed towards that side which is colder; therefore, in general, towards the left and backwards; on account of the rapid diminution of temperature towards the east in winter in Europe the exterior isobars of the depression extend especially toward the east, therefore more or less forwards, so that if the position of a center were in general determined by these isobars a shoving towards the front would apparently exist. The ordinary expression "axis of the whirl is inclined forwards or backwards," which is also used by Clement Ley, leads to misunderstanding. A simple mathematical axis for the whole whirl never exists in our great cyclones; these must stand perpendicularly on the plane of rotation, and in fact many authors in early and recent times, in speaking of the inclination of the axis of the whirl, have assumed a corresponding inclination of the plane of rotation. In truth, however, in the case of a cyclone we are dealing with a superposition of very thin nearly horizontal disks whose vertical axes of rotation do not coincide, but each of which is shoved a little toward the colder side as compared with the one lying immediately below. (*D. M. Z.*, I, p. 168.)

291. Dr. C. Lang, of Munich, contributes a long review of Ferrari's study of thunder-storms in Italy. The observation of thunder-storms has been conducted in Italy since 1876 in very much the same manner as it has been for a long time in France and Scandinavia. Ferrari's monograph is divided into two sections: First, the observations; second, climatological study; third, a dynamic study. The greatest frequency of thunder-storms per square myriameter is in Upper and Central Italy, whence it diminishes rapidly towards the south, being most frequent in a band nearer the east coast of the peninsula; the region of least frequency is the whole west coast. This geographical distribution, however, may be somewhat affected by the geographical distribution of observers, which are also fewest on the west coast, and for whose distribution Ferrari has made an approximate correction. The month of greatest frequency is July for Northern Italy, but the epoch is delayed as we proceed southward until it becomes August and September for southern stations. The annual frequency of hail shows no strongly marked features; the neighborhood of the Po has a slight immunity, and the frequency increases northward, but again diminishes close to the foot-hills of the Alps. The frequency of ordinary thunder-storms is as usual greatest between noon and 6 p. m., which quarter of the day

has a relative number 40, while from 6 p. m. to midnight the number is 32. More than two-thirds of the thunder-storms come from the west and depart toward the east. The wind prevailing during the storm is most frequently from between west and north. In general rain accompanies thunder-storms, and this is more intense in the hilly regions than in the plains. The monthly frequency of hail is nearly the same as the annual frequency of thunder-storms. The second portion of Ferrari's work, or the study of the mechanism of a thunder-storm, is the larger and more important. He gives here detailed studies of those storms that occurred between April 30 and September 17, and for each of which he has at least a hundred observations; charts are published in full of ninety-five storms occurring on twenty-eight days. The charts show the hourly isochromes for the beginning and end of each storm. Ferrari has drawn these lines after smoothing away individual differences; a process that may, however, hide from notice some important phenomena. The cold air that accompanies or immediately succeeds a thunder-storm is by Ferrari explained as due to a rapid descent of the air from the higher regions, but this is opposed by Dr. Lang, who thinks it is rather due to the cooling of the air by precipitation, especially hail. The intensity of the thunder and lightning is, after allowing for local influences, more considerable in extended typical thunder-storms than in those of small dimensions, and increases as the annual curve of temperature rises. Ferrari finds that distant heat lightning does not exist except in connection with thunder-storms there present.

292. [It was Professor Henry who first showed that in such cases the thunder from distant storms might in its progress downwards towards the observer suffer total reflection, and thus be carried over him above his head.] The shapes of the thunder-storms are generally long bands. In general Ferrari's conclusions are in agreement with those quite independently evolved a little later by von Bezold from his studies in Bavaria. (*Z. O. G. M.*, XIX, p. 353.)

293. Prof E. Landolt, from an elaborate study of the severe hail and thunder storms of the 21st of July, 1881, arrives at the following conclusions: (1) In very heavy thunder-storms the clouds are only a hundred meters above the earth, and the hail-stones form in the lowest strata of air; (2), the topography of the earth has a great influence upon the distribution of the storms; (3), the directions of the strongest currents of air dependent upon the thunder-storm follow the axis of the storm, and sometimes precede it, and the air flows from both sides toward the storm-center; (4), forests, especially when they crown the hilltops, moderate the extent and severity of the hail; (5), the hailfall can be very severe even on high regions that extend near to the thunder-cloud. (*Z. O. G. M.*, XVII, p. 254.)

294. Prof. W. von Bezold, of Munich, gives an account of the methods pursued by him for investigating thunder-storms in Bavaria and Wurtemburg. The ordinary postal card is converted into a form for the

record of the storms—the blank spaces can be rapidly filled out, suggesting, as they do, to the most inexperienced observer, the items that Bezold desires. The reports received during 1882 amount to over 5,000, and come from over 300 stations. These reports are studied by entering upon a chart for each station the time at which the first thunder was heard and arrows showing the direction from which the storm came and toward which it moved. Lines are then drawn called isobrontons, or lines of simultaneous appearance of thunder; these are drawn for the full hours, and give a beautiful picture of the progress of the thunder-storm. This procedure differs from that which is customary in France, Norway, &c., where the attempt is made to picture the progress of the center of the storm by taking the mean moment between the first and last thunder. Bezold prefers to draw isobrontons for the last thunder-claps as well as for the first so far as this is possible, but generally finds it difficult to get reliable reports of this last phenomenon. He has also, for the years 1881 and 1882, taken special care to reduce his barometric observations and to draw isobars of great accuracy, as a means of studying the relation of a thunder-storm thereto. His conclusions may be summarized as follows:

(1.) Thunder-storms that do not accompany heavy hurricanes originate when there arise in quiet air notable local differences of temperature and pressure. The isobars drawn for every 5 millimeters show only distortions, but by drawing them more minutely, say for every millimeter, they show definite centers. These small depressions appear mostly only as partial or auxiliary depressions in a great area of low pressure. The progression of the thunder-storm in general takes place without reference to the winds immediately attending these small depressions, but in accordance with winds that evidently prevail in the higher regions in connection with the great barometric depression. Especially intense are the thunder-storms that occur in a ridge of high pressure separating two great depressions.

(2.) If we draw a line inclosing the regions at which in a given instant the first and last thunders are being heard we inclose a space over which electric discharges are then going on. This is the area of the thunder-storm proper, and, in most cases, this region has the form of a narrow band perpendicular to the direction in which the thunder-storm is moving; therefore, in general, the storms move with a very broad front and very shallow depth. Cases are at hand where with a front of 300 kilometers we have a breadth of only 40.

295. [This peculiarity was long since remarked by the present writer, who in 1873 called attention to the fact that numerous thunder-storms and even tornadoes frequently occur nearly simultaneously on what appears to be the advancing edge of a broad area of cool or dry and therefore dense air; it is therefore not proper to say that the thunder-storm cools the air, but rather that the thunder-storm marks the progress of the advancing cool air, which by uplifting the moist air in front of it is

producing cloud and rain; it is the downfall of rain which, acting like the water-dropper of Sir William Thomson, discharges the electricity from uprising masses of moist air and cloud, and produces those differences of electric potential that give rise to lightning and thunder.]

(3.) There are definite regions that are especially favorable to the formation of thunder-storms, such as for instance the swampy lowlands between the larger lakes and the Alps; so also the west slope of the Bohemian forests very often gives rise to thunder-storms.

(4.) In those cases where the formation of a thunder-storm entirely within the area of observation can be clearly proven, the remarkable phenomena is noticed that over long distances the electric discharges begin simultaneously, so far as this can be determined with ordinary clocks; we are thus forced to the idea that the disturbance of electric equilibrium due to the first stroke of lightning is immediately communicated by induction from cloud to cloud, and thus provokes a simultaneous outbreak at various places.

(5.) The observations of heat lightning or distant silent lightning are interesting as showing the extraordinarily great distances to which this can be observed; thus on August 26, 1880, lightning was observed in the horizon at stations in Saxe-Meiningen that belonged to a thunder-storm then prevailing 240 kilometers distant near Ulm; and on December 9, 1882, lightning was observed in the south that seems to have belonged to storms 270 kilometers distant.

296. [Observations similar to these have doubtless been made by many others, and the present writer, after having satisfied himself that with Washington as a center lightning was frequently observed occurring near Norfolk and central Pennsylvania, proposed in 1872 to map out the course of all such storms by means of observations of azimuth and time to be made at all the regular Signal-Service stations; special directions were then given to signal-service observers to record carefully these phenomena in the journal kept at each station. The result proved that the observed azimuths were not generally recorded with sufficient accuracy; an apparatus to obviate this difficulty was designed but not introduced; the lines of equal thunder-storm frequency in the monthly weather review for July, 1874, were largely based upon the study of such records.]

(6.) The diurnal periodicity of the distribution of thunder-storms shows that besides the maximum between 2 and 5 P. M., there is also a secondary maximum between 2 and 3 A. M. (*Z. O. G. M.*, XVIII, p. 200.)

297. Von Bezold returns again to this subject in August, 1883, and dwells especially on the circumstance, that with the outbreak of a thunder-storm there often occurs a decided fall of temperature and sudden rise of pressure. As he looks upon the crowding together of isobars as the cause of a thunder-storm he enforced the following sentences:

On the front side of the band of simultaneous electric discharges, which band is perpendicular to the direction of progress and therefore

a little in front of the region of the thunder-storm, there exist peculiar temperature and pressure relations, namely, the pressure as we approach the storm from the front suddenly rises and the temperature falls.

The front edge of the storm sharply separates an area of high pressure from one of low, and equally separates an area of low temperature from one of high.

By considering the wind directions at the moment of the outbreak of a thunder-storm we find that on the front edge, in general, the winds are perpendicular to the isobars, if the latter run north and south, or that the wind blows direct from the high pressure to the low pressure, constituting a departure from the law of Buys-Ballot.

The existence of this sharply-defined passage from high to low pressure and from high to low temperature is so uniform that it is sufficient to study these isobars and isotherms in order to ascertain where the front of the thunder-storm is at any moment. (*Z. O. G. M.*, XVIII, p. 281.)

298. [For most of the thunder-storms that the present writer has examined or observed personally in this country and Europe he is convinced that the explanation of the outflowing cool wind immediately in front of the storm was correctly given by Espy at least as early as 1838. This wind is by him and Professor Henry explained as almost wholly due to the air dragged down by the falling rain and also cooled and rendered heavier, which, striking the ground, must be pushed out. But as the storm is undoubtedly advancing, either with the front edge of an extensive area of denser air, or else is being carried along within a great current of air, it follows, in either case, that the wind due to the down-rush of rain will compound with the wind due to the general motion of the atmosphere; we therefore generally find strong outward-going winds on one side of a thunder-storm and light outward winds or calms on the other side of the rain. Ferrel shows that no great barometer fall can be caused by these straight-out winds; there must be a rotation to produce a depression; on the contrary, air pushed down against the earth and outwards may cause a slight temporary rise of pressure, so that gusts and a sudden barometrical rise occur simultaneously.]

299. Dr. W. Köppen has given an exhaustive study of the destructive thunder-storm of August 9, 1881. The chart accompanying his essay shows that at 2 P. M. a low barometer was central just south of Norway and east of Denmark, while in the southeast quadrant from this, from Denmark to Bavaria, numerous thunder-storms occurred. The study of these storms seem to him to afford a striking example by which to test the conclusions of his previous investigation, well known as "Contributions to our Knowledge of Böen and Thunder-Storms," to which the present study forms a second memoir. After a minute description of the phenomena, follows a comparison and discussion on the causes and explanation of the thunder-storm from which Hann makes the following

summary, bearing especially upon the Böen or wind-gusts that accompany the thunder-storm.

Throughout its entire course the Böen was associated with the existence of an extraordinary well-developed change in pressure and temperature. This temperature distribution, as shown by closely compressed isotherms, corresponded to a very steep barometric gradient which averaged 9 millimeters at the place of most compressed isotherms. The object of the following is to explain how this extreme condition could originate. In the region which was later in the day to be visited by the Böen, there was already on the 8th of August a feeble southerly current and strong insolation with a temperature high above that prevailing to the westward, and which in Leipsic rose to 29.7 C., by noon of the 9th. This high temperature relative to the surroundings must have given rise to the formation of a low pressure at the base of the warm column of air. But that the isotherms should be so closely crowded is due to the fact that on the border of the warm and cold air, rainfall was caused by the uplifting of the former, which materially cooled this region and thereby propagated the phenomena toward the direction of the warm mass of air. With the heavy rain that thus originated air must have been dragged down mechanically with the drops and also must have sunk down in consequence of its lower temperature and greater density. The dynamic warming of this air could only be slight because of its mixture with water, and the downfalling cold air must have exerted a strong uplifting effect upon the warm air below and adjoining it, and thus the phenomena continually increased in severity. Thus, precisely on the limit of the warm region the production of cold was most intense; in fact we see the greatest crowding of isotherms there where the precipitation is heaviest in the Böen, and where it partly fell in the form of hail. The difference of temperature between Neustadt and Segeberg at 2 P. M. was 26°.1—14°.6 or 11°.5 C., for only 39 kilometers distance. Köppen attributes the retardation of the lower stronger gradients to friction at the surface of the ground, thereby causing the steepness of the change of pressure. The effect of this steep gradient is felt almost entirely in the acceleration given to the outflowing mass of air, because its movement is nearly in the direction of this gradient. [The gradient represents a constant force pushing outwards like gravity pulling downwards.] The slight value of the angle between the gradient and the wind is ascribed partly to the acceleration, partly to the circumstance that the air drawn into the Böen already has a motion nearly in the direction of the gradient. This distribution of pressure by reason of the great horizontal temperature gradient must change very rapidly with the altitude, and Dr. Köppen computes that, at an altitude from 600 to 700 meters, the irregularities in the isobars have disappeared and they have become simple ellipses inclosing the principal depression. At the place where the warm air is lifted up in front of the Böen thick masses of clouds must form, which move with the general air-current towards

east and northeast and cause heavy rainfall. The Böen is thus presented as a whirl around a horizontal axis. Köppen states that, since his first memoir in 1879, a slight change in his views has taken place, in that although he retains the important feature of the descent of cool air driven down by its density and falling rain-drops, yet he does not give so great an importance to this falling air as he did before.

In general, on the southeast side of any barometric depression, insolation causes a very warm region and at the same time, within a few hundred meters of the earth's surface, a subsidiary depression, although in the atmosphere immediately above this the isobars retain their elliptical form. The eastern portion of this region is thus withdrawn from the influence of the cooling current on the west side, and as a feeble southeast current increases in temperature. The western part, on the other hand, is early overflowed by the cool air from the west, which, by reason of the progressive movement of the principal depression, always comes from a more northerly point. By the pushing up of the warmer air rain is caused on this limit of the warm and cool region. By this, lower temperatures are caused close to the limit of high temperatures, and a temperature gradient produced which, following both the general current of air and the perpetually renewed precipitation on the temporary edge of the warm region, moves toward the side of the higher temperature. By this temperature gradient combined with the conditions of motion a pressure gradient is produced in the lower 600 meters of air which propagates itself in the same direction. This pressure gradient (favored by the fact that the remaining or horizontal distribution of pressure both above and below causes a current that flows approximately with that due to the steep gradient) causes an extraordinarily strong wind along the whole breadth of the region during its passage over, which usually lasts about twenty minutes. This stormy portion of the current is about two-thirds due to the air dragged by the downfalling mass of rain, while in front of it the air is ascending. Special places in this stormy region, which generally crosses the southwest current almost perpendicularly, are distinguished by special intensity of the storm, and other portions by a formation of hail. There thus originate regions of hail storm and of destruction, as evidences of the passage of the storm, and whose greatest diameters are approximately perpendicular to the greatest temporary extension of the Böen. So long as the thunder-storm moves against the sun it is subject to the influence of a daily period, since it originates in the morning, is best developed wherever it may be at the warmest time of day, and then with the beginning of the night rapidly diminishes in strength and soon disappears. (*Z. O. G. M.*, XIX, p. 12.)

300. [If we properly appreciate the points made by Dr. Köppen in his beautiful study, we should say that that which is thoroughly novel is the bringing out so clearly the fact that when once the development of the thunder cloud has reached the point of decided rainfall, and with

attending downward currents of air, the process from that time on may become a self-supporting one, each feature continually increasing in intensity until a maximum is reached, dependent on temperature, moisture, and configuration of the earth's surface, when it attains a condition of equilibrium, and so continues until nightfall. Köppen's study applies equally to every form of thunder-storm, tornado, and wind-squall. The views developed by him in this essay are accompanied by such a mass of exact data as to make it an invaluable contribution to our knowledge of a subject that was however already largely elucidated by Espy, Fourth Meteorological Report, pp. 106, 164, 165, and Prof. Joseph Henry, Lectures on Meteorology, Agricultural Reports, 1854 to 1859. In fact, we think it would not be an injustice to call the above the Köppen-Espy theory of thunder-storms and squalls.]

301. C. Ferrari writes in reference to Lancaster, Köppen, and von Bezold, who maintain that thunder-storms are caused by the small special barometric depressions, that he himself in his previous publications had really long before defended the same conclusions, and that he was the first from a complete investigation to demonstrate by observation the truth of these views. (*Z. O. G. M.*, XVIII, p. 426.)

302. Dr. G. Hellmann, in reply to Ferrari's reclamation, states that many have published their views on the connection between the thunder-storms and atmospheric pressure; thus the fact that the barometer suddenly rises at the outbreak of a thunder-storm and subsequently falls was, as far as he knows, first recorded by J. J. Planer, in 1782. Rosenthal, and especially Lichtenberg, in 1784, gave a very clear description of the whole process. Equally clear and apparently independent of each other are Gronau (1821), Strehlke (1830), and Kämtz (1836). (*Z. O. G. M.*, XIX, p. 44)

303. M. Möller discusses the suggestion thrown out by von Bezold to the effect that the winds in thunder-storms and Böen agree with the direction of the gradients, and do not correspond with the law of Buys-Ballot. This latter law, Möller states, affirms that, as a result of the acceleration due to the gradients, and under the influence of constant friction and by reason of the deflecting force of the earth's rotation, there will for equal latitudes result also equal deviations of the wind from the direction of the gradients. It has many times been shown how this deflection must decrease if the air passes from strong to feeble gradients. On the other hand, the reverse has not been stated, namely, that a length of time to be counted by many hours is necessary to communicate to a mass of air a motion deviating from the direction of the gradients, provided the air was originally at rest or did not possess such deviation. By a little computation Möller shows that for short distances and steep gradients, such as occur near a thunder-storm, the air—impelled by the difference of barometic pressure, and having both a forward velocity and a deviation due to the earth's rotation—although it obeys them both, yet appears to obey only the first of these forces, be-

cause that is over forty times larger than the second. (*Z. O. G. M.*, XIX, p. 80.)

304. M. Möller, in his investigation on the temperature and movement of the air in a Böen, states that in 1880 he first recorded the suggestion that the shadows of the clouds caused strong winds, which, acting like gusts, are called Böen, and which accompany the streaks of rain from cumulus clouds. This explanation, however, seemed unsatisfactory, because such wind-gusts occur also at night time, when, of course, there are no shadows. The true explanation has, he thinks, been given by Köppen, namely, that the falling rain carries with it air from above, which on reaching the ground spreads out and increases the strength of the prevailing wind. Combining his own and Köppen's ideas, he develops carefully the structure and growth of a thunder-storm, and succeeds in explaining very satisfactorily the mode of formation of hail and the low-lying scud in advance of the main cloud, and which the observer generally easily recognizes as rising up to feed the advancing edge of the cloud. (*D. M. Z.*, I, p. 230.)

305. [Views similar, and in most respects identical with Köppen's and Möller's, have during the last twenty years been frequently verbally communicated both by Prof. Joseph Henry and the present writer to fellow-students of meteorology. They date at least as far back as 1838, when Espy was in the full tide of his studies of thunder-storms in Pennsylvania, a region where storms are developed to their fullest extent.

Our hearty appreciation of the views of Köppen and Möller is enhanced by their own kindly mention of that most genial of American enthusiasts.]

306. C. G. Finemann, of Upsala, in a study upon the "trombe," or tornado, of June 7, 1882, draws the following conclusions:

1. The formation of a tornado is characterized by the simultaneous occurrence of great relative and absolute moisture, high temperature, almost perfect calm.

2. Tornadoes and thunder-storms originate under almost identical atmospheric conditions.

3. The two phenomena can occur together or separately.

4. Finley's work seems to suggest that either phenomenon may develop from the other.

5. The tornado here studied certainly consisted in a strong ascending current of air, revolving also in a direction opposed to that of the hands of a watch lying face upwards on the ground.

6. The ascending current formed an inverted cone out of the material carried up with it, which moved forwards towards the northeast.

7. The tornado was fed by moist air, which flowed over the earth's surface with increasing velocity.

8. The moister the air by so much more did the interior velocity of the tornado increase.

9. The air was precipitated into the tornado from below, like cold air

drawn into the fire of a burning forest; at some distance this draft was noticeable by the lowering of the lower portion of the clouds.

10. Subsidiary whirls formed under favorable circumstances. (*Z. O. G. M.*, XIX, p. 262.)

307. William M. Davis, of Cambridge, writing to Dr. Köppen in reference to the simoom [German, *Samum*], the latter replies by quoting the following as the characteristics of the simoom as experienced in the Indian deserts by Dr. Henry Cook:

Its beginning is sudden; occasionally a cold current of air precedes it; it occurs ordinarily in the hot months, June and July; it occurs in the night as well as by day; its path is straight and definite; its passage leaves a narrow trail behind; it burns and kills the animals and vegetables in its path; it is accompanied by a very noticeable smell of sulphur; it is described as like the current of air from a furnace, and certainly the temperature of the air within it is very high; it is not accompanied by either dust or thunder and lightning.

Köppen shows that, assuming the rise of temperature in the simoom to be 16° C., then, if the air has been thus heated by the compression of a descending current, it must have descended about 4,000 meters; but he thinks it not at all plain why the air should descend to the earth's surface. There is not a perfect parallelism between the simoom and ordinary Böen, nor an antithesis between Böen and thunder-storms. (*D. M. Z.*, I, p. 245.)

308. A. Klossowskij has discussed the observations of thunder-storms made in Russia by the observers of the Geographical Association since 1871. This series of reports was inaugurated at the instance of A. Woeikof, who also published the results for the first year (1871). The present volume gives a complete summary of the work since that time.

309. J. Ludevig presents the results of the observations of thunder-storms made during 1882–'83, at the Government telegraph stations in Germany. The maximum number of storms occurred in May, 1882, but this was apparently abnormal; the normal maximum appears in July, 1882, and again in July, 1883. The maximum number of days on which thunder-storms occurred was 28 in June, 1882, and 30 in June, 1883, The storms came most frequently from the southwest and next frequently from the west; the hours during which most storms occur is from 3 to 4 P. M., and the minimum frequency of storms from 12 to 3 A. M. (*Z. O. G. M.*, XIX, p. 429.)

310. Dr. P. Andries, in a memoir on formation of thunder-storms and hail, after a review of the older literature on the subject, adopts mechanical theories very similar to those of Ferrel in his Meteorological Researches, part 2. With regard to the formation of a potential sufficient to produce lightning, he adopts the view that this is explained by the combination in one of numerous small drops of water; as to the origin of electricity on these small particles, he attributes that to friction

and induction. (*Annalen der Hydrographie und maritimen Meteorologie*, 1884, p. 65.)

311. Prof. James Thomson, of the University of Glasgow, read before the Montreal meeting of the Brit. Assoc., a paper on whirlwinds and water-spouts, in which he adheres to the old view that the diminution of pressure observed at the center of a hurricane is the cause of the movement of the wind, and queries whether it may not be possible for the low pressure to be abated through the combined influence of rarefaction by heat and the whirling motion. He also thinks that in great whirlwinds the whirling motion may be propagated upwards to the top of the atmosphere. He suggests that the dark clouds, and in tornadoes the pendent spout, may be due to the precipitation of moisture on account of abatement of pressure due to centrifugal force and ascension above the sea level. [Prof. James Thomson's publications on this subject date from 1852, and especially 1857, but while his writings are always worthy of attention, it would seem that these particular points have already been clearly explained by other students of meteorology.] (*Nature*, xxx, p. 648.)

312. Prof. W. von Bezold, of Munich, has studied the question of the cold days in May. He finds that whenever high pressure prevails in the west and lower pressure in the east, and especially in southeastern Europe, a cold period occurs, and that this distribution of pressure is particularly liable to occur in May. If this characteristic distribution fails, then the cold days also fail; the explanation of the cold days is therefore dependent upon the explanation of the occurrence of this distribution of pressure. After studying the isobars of Europe, he concludes that when in spring the warming of the northern hemisphere begins at the south and oceans and continents interchange their relations with reference to pressure and temperature, then the Balkan peninsula, together with the land between the Adriatic and Black Sea, plays the part of a small continent. It is therefore warmed up with reference to the surrounding region, experiences a low barometric pressure, and especially favors the development of storm-centers. These, therefore, cause the cool northerly winds and the cold days of Germany. (*Z. O. G. M.* XVIII, p. 268.)

313. Dr. Köppen, in reference to the cold days in May, states that neither the explanations of Mädler, Erman, Sainte Claire-Deville, Assmann, von Bezold, nor others seem to him to afford any satisfactory explanation of the question why the precise days from the 10th to the 13th should have such a decided tendency to be abnormally cold. (*Z. O. G. M.*, XIX, p. 133.)

314. R. Billwiller states that he has been surprised that van Bebber, in his essay on the cold days in May, has so strongly stated that these always happened on definite dates, whereas Dove had so clearly proved that they are not simultaneous in different localities, nor do they happen on a definite date at any one locality, whence Dove considers that

any cosmic cause is out of the question. Now that this conclusion has been confirmed by von Bezold by his demonstration of their purely terrestrial cause, and that they occur pretty uniformly distributed through a long interval of time, it seems strange that Köppen should state that the main point of the question has not yet been touched, and should again suggest cosmic explanations. Billwiller's opinion is that there are no facts on record from which we can philosophically conclude that there are three definite cold days in May or that there is any problem here to be investigated. [In other words, this problem is to the German what the problem of the equinoctial storm is to the American. Whatever storm happens to occur within a week or two of the 21st of March or September is called the "equinoctial storm," and we frequently find some one at work on the problem, "Why are storms especially apt to occur on the equinoctial day?"] (*Z. O. G. M.*, XIX, p. 245.)

315. Dr. W. Köppen, in reply to Billwiller's remarks, states decidedly that he is not a believer in the three cold days of May, nor in their explanation by cosmic causes. The essence of the problem seems to him to lie in the following questions:

1. Is there really present that relative maximum tendency to cold days which, according to many, especially the older observations and according to the investigations of von Bezold, apparently exists during the third pentade of May?

2. If this is the case, how shall the date be exactly determined?

Even if the first question should be denied, it would still remain of interest to show why the tendency to a south and a southeast gradient—that is, to a northeast wind—should be so decided in May, and should also not exist in June, where the excess of temperature of the continents above the sea remains the same while north and northeast gradients prevail. He shows that this may be due to the heating of distant lands, and remarks that also the studies of Dr. Krankenhagen on the barometric phenomena attending the cold period in June combine to show that in severely judging the belief in the definite character of special days we may have gone too far.

316. Buys-Ballot writes expressing his entire agreement with Professor Billwiller. He states that every month has its cold days, and May least of all, and suggests a method of investigation which he is about carrying on. In a parenthesis he exclaims, "Shame, that in America climatology is so entirely lost sight of!" (*Z. O. G. M.*, XIX, p. 320.)

317. G. Hellmann, in a study of the annual change of temperature in Northern Germany, utilizes the averages by pentades for thirty-five years; he finds a decided retrogression or cold period about the middle of June for Breslau. The cold days of May vary so much as to their dates that they do not show in the averages of thirty-five years, while the cold days of June are well marked. Another retrogression, but in this case warm days, occur in the last week of September. (*Z. O. G. M.*, XIX, p. 384.)

318. Dr. Krankenhagen, of Stettin, has investigated the distribution of temperature and pressure in Europe in June, and has shown that the pentade, June 10 to 14, is peculiarly liable to a slight fall of temperature, while on the other hand the isobars of June require such winds as must produce this temperature fall. In general the areas of low pressure that pass over Europe have a tendency to take a direction toward the northeast, east, or southeast, and are therefore followed by cold winds. (*D. M. Z.*, I, p. 11.)

319. Dr. Krankenhagen also contributes to the question of three cold days in May a study based on the consideration that such may be caused by especially cold, clear nights; he therefore calculates how many days have been above the mean, and how many below; the mean negative departure we may call X, and positive departure Y; then the quotient X ÷ Y shows how many more times the mean negative departure is greater than the positive. This ratio is 1.16 for the third pentade of May. (*D. M. Z.*, I, p. 371.)

320. Dr. J. van Bebber, of the Hamburg Seewarte, publishes the results of a study into typical weather phenomena in anticipation of a more exhaustive publication by the Seewarte. This is a continuation of his studies upon the geographical distribution, the paths and velocities of barometric minima; his object now being to ascertain in what manner these depressions influence the condition of the weather, especially in Germany, and whether it is not possible from any given condition of the weather to deduce practical rules for predicting the movement of the depressions and the future weather. He first determines the principal paths followed by the majority of the storm centers, leaving to a future time the study of the erratic minima. The tabular view of the frequency with which storms traversed these principal paths shows a decided tendency of minima to follow in groups along any path once inaugurated by a leading storm. He also shows that the mean velocity of minima moving along the paths is always much greater than the general mean velocity of all minima indiscriminately. Therefore we conclude that along these principal paths the conditions are most favorable for maintaining the intensity and rapid progress of minima. If we consider the distribution of pressure for each of these paths separately, we find characteristic relations; thus, if a line be drawn from the minimum to the maximum pressure, or from the minimum normal to the closest isobars, we find the storm progress nearly perpendicular to this line; in other words, the progress of the minimum agrees closely with the direction of the strongest wind, thus agreeing entirely with the principle announced in 1872 by Rev. Clement Ley, namely, "extensive areas of very high pressure delay or turn aside the movement of a depression, in that each depression moves with the greatest ease in a direction such that it shall have the highest pressure on the right-hand side of its path."

A relation is also apparent between the distribution of temperature

and the progress of depressions so that the direction of the movement forms an angle with the direction of the greatest rise of temperature, which angle varies between 45 and 90 degrees, being greater in summer than in winter, the highest temperature being on the right-hand side of the storm path. This principle is also indicated by Clement Ley in the following words: "The direction of progress of depressions in Western Europe varies in Europe between north-northeast and south-southeast, and is primarily dependent on the preceding general distribution of temperature, so that the movement is inclined at an angle of 45 degrees to the lower isotherms." These principles, announced 11 years ago in England, have, says van Bebber, not found the proper consideration in European weather predictions. After some explanatory words, he sums them both up in the following: The progress of depressions takes place approximately in the direction of the prevailing movement of the whole mass of air in the neighborhood of a depression. This statement would seem to support the assumption that the atmospheric whirl is carried along by the prevailing current of air. [We are now giving van Bebber's statements nearly in his own words and reserve the privilege of stating that, although the connection between the phenomena is very nearly as he gives it, yet the rationale of the process is, we think, not at all as he seems to suggest.] By reducing pressures upwards and constructing isobars for an altitude of 2,500 meters and also for higher altitudes, he is led to the conclusion that the whirlwind movement is confined only to the lower strata of air, that the axis of the whirl is inclined to the left and slightly towards the front, and that the upper currents of air in the neighborhood of the whirl have nearly the same direction, so that those belong to a great ring progressing with the depression and in which the air that rises within the depression now sinks again. This agrees with the fact that the movement of the cirrus clouds agrees with that of the progress of the depression; this also explains why the upper clouds, which also move with the depression, are so prominent in advance, while on the left side of the path the cirrus clouds are so infrequent; this also explains why the principal storm paths marked out by van Bebber are especially followed in the colder season of the year and why the storm paths, numbered 1 and 4 by him, moving towards the northeast or east-northeast, occur most frequently in the warm season. Equally easy is it to explain why a number of successive storms have a tendency to follow the path pursued by some prominent leading one, for if atmospheric pressure and temperature are so distributed over a large part of the hemisphere as to be favorable to the production of a given storm path, then it is clear that succeeding depressions will follow the same path so long as the distribution of temperature and pressure does not change, and as these changes can only go on slowly it necessarily happens that storms and local weather changes some times show great similarity for days and weeks together.

321. [It is certainly to be regretted that the intense study under most

favorable circumstances given continuously since 1870 to the tri-daily weather maps of the United States and Canada should not long ago have been supplemented by some general summary of the laws of storm progress and weather changes with which the officers of the Signal Service have become familiar. Guided by the writings of Redfield, Espy, Henry, and Ferrel, the deductive branch of meteorology was making rapid progress—greater than could possibly have been followed by those outside of the office. It was already in 1872 a matter of common note that storms and also areas of high pressure, &c., pursue successively the same or very similar paths, each one showing a progressive systematic difference from its predecessor, until by a sudden change in distant surrounding circumstances the whole system was broken up and a new order of things inaugurated. These similarities between storm paths were frequently pointed out, both in the daily weather predictions and the Monthly Weather Review. An interesting illustration of this will be found in the daily predictions of the hurricanes of August 18 and 25, 1871, as made by the present writer for the official weather "Synopsis and probabilities" of the Army Signal Office.]

Van Bebber continues by saying that only in the rarest cases are pressure and temperature distributed around two storm-centers in the same manner, and to this circumstance principally is it to be attributed that the progress of and changes in the depressions show such extraordinary variety. If the distribution of pressure and temperature is reversed, then will the movement of the depression be hindered or entirely annulled, and at the same time it itself takes a long irregular form [the barometric trough of the Signal Service Bulletins], its longer axis perpendicular to the pressure gradients, and from its ends frequent small minima break off that then follow the general current of air prevailing in their region; if, however, on either side pressure or temperature prevail, then the direction of the movement of the storm-center will be thereby determined.

From this short explanation we see the great importance of these two principles in their application to weather predictions. If, however, we would form a correct prediction, we must extend our weather map to the greatest possible extent, especially toward the west, and study expressly the behavior of the great barometric maxima and minima that characterize certain regions of the earth. We see also the importance of the study of the cloud movements, especially the upper clouds. (*Z. O. G. M.*, XVIII, p. 447.)

322. Teisserenc de Bort having studied the general weather conditions attending abnormal winters, further develops his generalizations relative to the "principal centers of action of the atmosphere," and shows that the perturbations in the position and intensity of these atmospheric centers correspond with important changes in the character of the weather. If, therefore, we would predict the weather for a long

time in advance we must determine the connection between the local weather and the general circulation over a large part of the earth's surface as due to these centers. (*Z. O. G. M.*, XIX, p. 105.)

323. [The centers of action, as he calls them, seem to be identical with the large areas of maximum and minimum pressure first marked out by the isobars of Buchan and generally known to meteorologists as continental and oceanic maxima and minima. Teisserenc de Bort gives in detail the types of weather peculiar to France for each location of the surrounding maxima and minima areas, but the assumption running through his essay to the effect that the changes of local weather are directly due to the changes in the pleiobars and meiobars, as they were called by Prestel, seems to us quite unwarranted. This matter is referred to in a circular of the Signal Office, published in June, 1871, "How to use weather maps," and was for several years carefully studied from Teisserenc de Bort's present point of view, but the present writer was forced to the conclusion that some ulterior forces controlled both the local weather and the permanent or subpermanent highs and lows, so that although it is very convenient, for instance, to connect our Atlantic coast weather with the Atlantic area of high pressure between latitudes 20 and 30 degrees, yet it is not possible to say that the latter is cause and the other effect.]

324. H. H. Hildebrandsson has still further investigated the average distribution of meteorological elements, wind, clouds, temperature, rain, haze, or fog, with reference to the isobars; he divides these latter into five zones, namely, the low center, three intermediate bands, and the high area. Each of these zones he divides into eight portions according as the gradient therein is directed toward the north, northwest, &c. The examination of six years of weather maps shows that for Upsala and for southern and central Sweden the following generalizations hold good:

1. The wind makes a greater angle with the gradient in summer than in winter and within a minimum than within a maximum; greater at sea than on land; greater for gradients directed towards the east and least for those towards the west. The strength of the wind is greatest for gradients directed towards the north and least for those towards the west and southwest.

2. The lower clouds move in directions deviating to the right from the direction of the wind at the earth's surface; the lower clouds move nearly perpendicular to the gradients or parallel to the tangents of the isobars; for gradients towards the west the lower clouds are inclined more than 90°; that is to say, the air is moving away from the area of low pressure.

3. The cirrus clouds move from the minima out towards the maxima; this movement is feeblest near the center of depression and most rapid within the maximum zone; the movement is greater on the advancing side of a depression, or on the western side of a maximum; directly be-

hind and above a low center the movement in the upper regions is for Sweden ordinarily from north or west, but there are cases in which the movement is from south or southeast, which latter is the ordinary case in England, according to Clement Ley.

4. The temperature in the maxima and minima areas is above the mean if the gradients incline towards the west, and below the mean if inclined towards the east; in winter the temperature is above its mean minimum and below in the maximum area; in summer this is reversed. The temperature differences between upper and lower stations are greatest when the gradient is directed towards the north or east, but least towards the south or west.

5. The quantity of clouds or rain are greatest for gradients towards the south or west and least towards the northeast.

6. The transparency of the air for distant objects is independent of barometric pressure; greatest fog occurs with gradients towards the west, but in the Kattegat the fog is most frequent for gradients towards the north. (*Z. O. G. M.*, XIX, p. 469.)

325. Prof. P. Busin, of Rome, has endeavored to indicate the various positions that areas of high and low pressure must have relative to Italy in order to produce any given type of weather; he computes a new kind of wind rose for Rome, showing the probability of various types of weather for numerous relative positions of the isobars; the number of these types may amount to about 100. He concludes that the changes in the barometer for intervals of more than eight hours, and equally so the changes of temperature for twenty-four hours, are of little use for weather predictions; he suggests that it will be probably of more use to study the departures of the temperature and pressure for the normal values of the day and the hour for which the weather map is drawn. (*Z. O. G. M.*, XIX, p. 235.)

326. [The actual pressures and temperatures and the departures have each their special significance—both are used by the Signal Office, but of the two the former has greater value in studying the mechanical laws of atmospheric motions.]

327. Dr. J. van Bebber, of Hamburg, reviews the works of Hoffmeyer and Teisserenc de Bort, as well as Hildebrandsson, on types of weather, and their connection with general distribution of temperature and pressure. In conclusion he says: "If we glance back upon the progress made in these [and his own equally extensive] works we must come to the conclusion that the prevailing character of the weather on any day in Germany is determined by the more general distribution of weather conditions, and that we shall only understand the general weather changes when we take into consideration the seasonal interchanging of the general centers of action in the atmosphere. But within this region [Europe] rapidly progressing changes are completed that can indeed have no important influence on the prevailing weather of the larger areas but that are of fundamental importance for the weather of small

regions. Often barometric minima, formed on the edge of the greater centers of depression, glide in rapid succession along the edge of the great barometric maxima, exerting upon the wind and weather of the region through which they pass in broad circles an extraordinary influence, and give the weather the character of variability. As a contribution to this subject, see my investigation on Typical Phenomena, which I wrote at the beginning of the year 1883 for the introduction to the volume of Monthly Weather Reviews for 1882, and which will soon be published in greater fullness in the *Archiv* of the Deutsche Seewarte. In this investigation the effects of the depressions upon the weather are referred back to the well-established main tracks of storms, and these are brought into connection with the general atmospheric conditions. These and similar studies give the first foundation for weather prediction for a long period in advance. We are persuaded that the weather predictions for such periods are not among the impossibilities, but that hereafter they will at some time exceed in usefulness the daily prediction." (*D. M. Z.*, I, pp. 22–70.)

328. [Predictions three and four days in advance based on similar considerations were made by the Signal Office in 1871 and 1872 on occasions of importance.]

X.—(*a*) Atmospheric electricity; Lightning; (*b*) Terrestrial magnetism; (*c*) Ground currents; (*d*) Auroras.

329. The subject of atmospheric electricity and terrestrial earth currents was dealt with by the Electrical Congress held at Paris April, 1884, which recommended that the different countries should collect reports and forward them annually to the International Bureau of Telegraph Administration at Berne, which bureau will digest and communicate a summary in return. It also recommended that observations of earth currents be made in all countries.

330. The United States National Conference of Electricians, meeting at Philadelphia in 1884, renewed these recommendations, commending them most heartily to the action of our Government, and appointing a committee to confer with the Chief Signal Officer, who is commissioned to collect the data for the United States, and who has already for two years been conducting preliminary observations on atmospheric electricity with a view to the addition of this item to the Signal Service daily report.

331. E. Hoppe publishes a history of electricity (Leipsic, 1884). This volume of 622 pages shows great industry on the part of the author, who has probably made his work quite as exhaustive as would be profitable to the most patient reader. He divides the progress in this science into the following epochs: (1) Before Franklin; (2) Franklin and Coulomb; (3) from Volta to 1819; (4) electricity and magnetism; (5) from Ohm to Helmholtz; (6) more recent progress. (*D. M. Z.*, I, p. 419.)

332. Prof. P. G. Tait, of Glasgow, in a lecture before the Scottish

Meteorological Society, gives his views on the source of the electricity of the air about as follows: The new kinetic theory of gases teaches that in a cubic inch of saturated aqueous vapor under atmospheric pressure there are contained some three hundred trillion of particles. This corresponds approximately to $\frac{1}{1600}$ of a cubic inch of water, or to one rain drop of ordinary size. When every particle of vapor becomes electrified for any reason, and all are at the same potential, then, after the union of all into one rain drop, the potential of the latter will be fifty billion times greater. From this it is evident that if from any reason every particle of vapor received so slight a potential that it is imperceptible to our most delicate electrometers, yet the formation of drops of water from these particles would explain the most terrible strokes of lightning. Some years ago it occurred to me that the simple contact of vapor particles with those of the air by the process of diffusion going on between them must be sufficient to produce this extremely small potential. Thus the source of atmospheric electricity is the contact of two snbstances, as in Volta's apparatus, where it is the contact of two dry metals. Experiments upon a small scale have not as yet confirmed this view, nor can it be thoroughly investigated without making them on so large a scale that private means are inadequate to cover the expense. (*Z. O. G. M.*, XIX, p. 301.)

333. Prof. P. G. Tait communicates a critical summary of all suggested theories as to the source of atmospheric electricity. His own contact theory is given above; the other theories may be briefly summarized as follows: (1) Aerial friction; (2) Pouillet, combustion and evaporation; (3) Saussure, vapor condensation; (4) Peltier; and von Lamont, the permanent negative electrical charge of the earth by conduction and induction electrifies the air and vapor; (5) Sir William Thomson, air is electrified by contact with the ground, and remains so after ascending in the ordinary convection currents; (6) Becquerel, electified corpuscles travel from the sun to the earth's atmosphere; (7) Mühry, a direct effect of solar radiation; (8) Lüddens, friction of vapor against the dry air; (9) The capillary surface tension of water drops; (10) The production of hail-storms; (11) Friction of air against the ground or against currents of air. (*Nature*, XIX, p. 517).

334. Prof. Edlund, of Stockholm, has endeavored to determine numerically the amount of the unipolar induction due to the relative movements of the atmosphere and the earth considered as a magnet. The measures which he has made in Stockholm give for a layer 1 meter thick at the equator an electro-motive force of 0.0321 Daniell's cell. Allowing that the moist air is a good conductor, and that the clouds have an average height of 1,000 meters, he reckons that between the earth and the clouds there must exist an electro-motive force of at least 23 Daniell's, which abundantly explains the electric tension ordinarily observed in the air. The extraordinary electric tension necessary to produce a lightning-flash originates according to him in the increase of tension

that takes place when the volume occupied by the aqueous vapor is so enormously diminished as in the formation of rain drops, a view that is apparently similar to that of Tait and other authorities. (*Z. O. G. M.*, XIX, p. 535).

335. Prof. H. Dufour communicates to the Swiss Scientific Association the results of his observations on the electricity of the air as made in the laboratory at Lausanne. From six months' observations with a Mascart self-register, he finds approximately the maxima at 7 A. M. and 9 P. M.; the minima between 3 and 5 P. M. and 3 and 4 A. M. Negative electricity occurs frequently during very hard snow; occasionally two successive precipitations separated by clearing weather show opposite electricities. The conditions recorded by the electrometer are very complicated; they depend upon the potential of the air at the water-dropper, and on the induction of electrical layers on the water dropping from the tube; in fact, the records of the electrometer are like those of a thermometer hung freely in the air whose temperature is that which results from conduction to the neighboring air and radiation to more distant objects. Dufour has attempted to separate the electric induction and conduction from each other as follows: The discharge tube was made to end in the center of a metallic cage of 40 centimeters cube, each of whose six metallic sides could be removed without disturbing the others. If the cage is entirely closed the electrometer shows the potential of the mass of air streaming through it; if one or other side be removed, the instrument comes under the additional influence of induction through a definite region of space.

Together with these observations, Dufour, by allowing drops of water to fall through unelectrified air, showed that electricity was more evident in air filled with water-dust than in pure air. Clouds of smoke from burning wet straw, carried in currents of air past the apparatus, showed for each cloud the presence of electricity, similarly clouds of steam from a tube communicating with the earth. If the air of a great hall was electrified and strong drafts produced within the hall, the electrometer showed variations similar to those recorded by the Mascart during the prevalence of north winds. Attempts to produce electricity in the air by the sudden condensation of vapor into fog gave negative results. (*Z. O. G. M.*, XIX, p. 129.)

336. Prof. L. Palmieri publishes a little memoir summing up all his works upon atmospheric electricity. According to him the electricity of the earth's surface is induced by that of the air. The potential of the air is always positive in clear sky, and so, also, during a cloudy sky, provided that no rain has fallen within 70 kilometers; but as soon as rain falls, positive and negative electricity rapidly alternate. Lightning can only occur during or in connection with rainfall. The origin of atmospheric electricity is, he thinks, to be found in the condensation of aqueous vapor. (*Z. O. G. M.*, XVIII, p. 80.)

337. Dr. S. Kalischer, of Berlin, has experimentally investigated the

condensation of steam as a cause of electrification, and finds wholly negative results. (*Nature*, XXIX, p. 227.)

338. G. Le Goarant de Tromelin publishes in the Comptes Rendus of Paris his theory that the principal cause of atmospheric electricity consists in the friction of moist masses of air on the surface of the earth or ocean. The electrified molecules of water rise above and form clouds on whose surface the electricity is expanded, which then gives occasion to lightning; during the afternoon and evening the water, vapor, and clouds, cool down, the electric tension on the individual particles of mist becomes greater, and the electric discharges known as heat-lightning occur. (*Paris, Comptes Rendus*, 1884, p. 248.)

339. Dr. Linns, of Darmstadt, in reference to the origin of atmospheric electricity, suggests a laboratory experiment which he thinks is new and will go far to elucidate his view of the subject, according to which the electricity of the rain and thunder clouds can only affect the instruments, and give the phenomena of high tension, through the separation in space of the two principal parts of the cloud, namely, the air and the vapor. The three fundamental questions are the following: (1) whether electricity is first formed during the fall of the precipitation possibly through its friction on the air, or (2) whether it is produced by the process of condensation itself, or (3) whether before the precipitation, in the mixture of air and vapor, the molecules of these components are not laden with the opposite electricities. Linns considers the latter as the most plausible, in view of our present knowledge of electricity, that in fact the electricity of the clouds results from the well-known phenomena of contact electricity observed in the contact of heterogenous bodies; the molecules of the components of a mixture of gases are, in consequence of the enormous number of impacts which, according to the latest theory, occurs in every second, oppositely electrified by contact; this electricity, however, can only produce an exterior effect through a rapid separation of the gases; the original mixture itself must always appear non-electric on account of the intimate mixture of the oppositely electrified molecules, and since the sum of the positive and negative electricities must be equal to each other. His proposed experiment looks to the rapid separation of the vapor and gas by absorption, and the experiment should succeed with other gases and vapors besides those of the atmosphere.

340. Dr. E. Hoppe, of Hamburg, having opposed this hypothesis from a theoretical point of view, Dr. Linns replies suggesting other experiments, and also states that he has now, since August, 1883, conducted observations on the loss or dissipation of electricity by conductors exposed to free atmosphere; he finds the loss least in winter, greatest in summer, less in the morning and evening, greater in the day-time. He proposes that lines of equal electric loss be constructed on the daily weather charts, by the study of which our knowledge of atmospheric electricity will be much assisted. (*D. M. Z.*, I, p. 464.)

341. Lieutenant Lephay, with a Mascart self-register and a water-dropping collector 3 meters above the earth's surface and 24 meters above the ocean, at the French international station at Cape Horn, deduces the following results as to atmospheric electricity:

1. The normal tension is positive and between 50 and 70 volts; its maximum occurs in clear sky and frosty weather.

2. The daily maxima and minima ordinarily observed were only apparent at the cape in beautiful weather, with clear, blue skies free of clouds.

3. Whenever the sky is beclouded after a fine day the normal tension immediately changes, and vice versa when the cloudiness clears away.

4. Clouds affect the electrometer in different ways, according to the form of the precipitated water, and even according to their direction from the observatory; cumuli increase the positive tension; high cirro-cumuli increase it still further to plus 400 volts; cirro-stratus seem to have no influence; fog and fine rain produce a positive tension that is sometimes very high.

5. With hail there always comes an extraordinary strong, negative tension, so that even sparks dart from the upper part of the apparatus.

6. Snow gives always a positive tension, and by so much the greater as the snowflakes are larger.

7. Rain, with four exceptions, always gave a negative tension.

8. A fall of snow-dust and small ice-crystals on the 8th of May occurred with a decided positive tension.

9. Of three sleet storms, two occurred with foggy weather, fine rain, and positive tension, and one with heavy rain and negative tension.

10. For twelve or fifteen hours before the outbreak of heavy winds and gusts the positive tension increased. It is not possible to say what tension prevails during the storm itself, since the rapid-passing clouds obscure the influence of the winds by their own more powerful effect. The dry, warm, north-northwest or northeast winds diminish the positive or increase the negative tension; the cold west, southwest, and south-southwest winds increase the positive tension. The strongest electric phenomena occurred with moist winds from the west-northwest and west-southwest. (*Z. O. G. M.*, XIX, p. 471.)

342. Prof. E. Mach has more accurately investigated the amount of protection from a lightning discharge, as actually experienced by an object inside of a metal box representing the wire-cage inclosure in Melsen's system of protection from lightning. He finds that although the theoretical explanation of Melsen's system must be slightly modified, still even when the wire of the cage is brought to a red heat by the lightning discharge the interior will be almost perfectly protected. (*Z. O. G. M.*, XIX, p. 264.)

343. Prof. J. J. Spartsch, of Breslau, in an essay on the climatology of Greece, states that the statistics of the thunder-storms, or of days on

which thunder is heard, shows that the island of Corfu belongs to a region in which electric discharges are more frequent than in any other part of Europe. (*Z. O. G. M.*, XIX, p. 123.)

344. P. von Salis, telegraph inspector, has collected a mass of statistics relative to lightning on telegraph lines, and at other stations during the past thirty years in three cantons of Switzerland. He finds—

1. That in a remarkable way, with extraordinarily few exceptions, and even then only where we may safely infer the presence of a great quantity of water in the ground, all and every lightning discharge occurs upon telegraph lines in the immediate neighborhood of a small or large brook or river; further, these also occurred in the case of the telegraph poles established for conveying submarine lines on the shore of the lakes and never occurred elsewhere.

2. That the lightning for the past thirty years has occurred more frequently on lines in the lowlands and valleys inclosed between high mountains than on the highest Alpine passes. This latter conclusion is borne out by the following table:

Altitude of the line.	Length of the line.	Number of lightning strokes.
M.	*Kilometers.*	
Under 500	226	16
1,000	263	4
1,500	156	4
2,000	196	6
2,500	65	1

(*Z. O. G. M.*, XVIII, p. 384.)

345. Prof. W. von Bezold has discussed the cases of destructive lightning in Bavaria during the years 1833 to 1882; this work is a continuation of a lesser work undertaken some fifteen years ago. Among his results we note that the frequency of destructive lightning when reduced to uniformity in the matter of buildings has almost steadily increased in forty years to more than three times its previous frequency, a remarkable phenomenon but apparently well established. As the principal object of his investigation, von Bezold presents on a chart the geographical distribution of lightning strokes for the year. (*D. M. Z.*, I, p. 339.)

346. Dr. Kayser exhibited to the Berlin branch of the Meteorological Society photographs of flashes of lightning, one of which showed four parallel flashes from top to bottom, which must have occurred simultaneously or in very close succession; his opinion was that a double discharge going and coming had occurred, the course of which (through air of least resistance) had of course been displaced by a strong wind. The amount of the displacement could be observed on the photographs whence he calculated the time between the first and second discharge. (*Nature*, XXX, p. 652.)

347. K. Schering, of Göttingen, describes a new instrument for determining the variations of the vertical component of terrestrial magnetic force. This has been used at Göttingen in connection with the International Polar Observations; it has an advantage in that it is entirely free from the perturbing influences of friction; is much less influenced by the torsion of the suspension thread and by the effect of temperature on the center of gravity of the needle, which consists of a magnetized steel tube 300 millimeters long and 10 millimeters interior diameter. (*Z. O. G. M.*, XIX, p. 547.)

348. A. L. von Tillo has collected together all possible data relative to the geographical distribution and secular variation of the magnetic declination and dip in European Russia. (*Z. O. G. M.*, XIX, p. 550.)

349. Dr. Guido Schenzl publishes in one volume the result of sixteen years' labor on terrestrial magnetism in Hungary. The observations extend from 1865 to 1879. All data are reduced to the normal station at Munich, and the normal epoch, 1875.0. The charts show by isogonic and other lines the general distribution of declination, dip, and intensity. (*Z. O. G. M.*, XVII, p. 248.)

350. E. E. Blavier, of Paris, having organized a very careful system of observations, publishes a study on earth currents, made in accordance with the suggestions of the Electrical Conference held at Paris in 1881. As director of the telegraphic administration of France, Blavier has had extensive opportunities and has used them skillfully. He finds the general direction of the line of maximum electro-motive force in France from northwest to southeast inclined 56° to the magnetic meridian. (*Nature*, XXX, p. 106.)

351. Prof. H. Wild has contributed to the subject of earth currents an important study upon those observed in his buried telegraph cables in the neighborhood of the observatory of Pavlosk. The principal series of observations previously made were those by Lamont, 1859, with lines only 100 meters long; Airy, 1862, with lines 13 and 16 kilometers long; Galli, 1880, lines 4 and 6 meters long. [Lieutenant Ray, at Point Barrow, 1882, used four lines, each of about 300 meters length.] Professor Wild used four lines, north, south, east, and west of the central magnetic observing station, which is itself underground. The lines of wire were each 1 kilometer in length, and crossed each other at the observatory, where the galvanometer was established. He deduces the following results:

1. In this neighborhood in seasons of magnetic calm the earth current is so feeble that its difference of potential for one kilometer is less than the uncertainty of our measurements, or 0.001 of the electro-motive force of one Daniell's cell.

2. The currents observed by Galli at Velletri, on his short line, were wholly due to the ground plates; those observed by Lamont were partly ground-plate and partly terrestrial currents; and those observed by

Airy on his long line undoubtedly show the presence of terrestrial currents, but there is no means of separating the one from the other.

3. In magnetic calms the difference of electric potential between ground plates 1 kilometer apart, so far as it is due to terrestrial currents, is less than 0.001 volt, while so far as due to the plates themselves it can easily amount to 0.05 volt, or even more; at times of magnetic perturbations it is only rarely that the first difference increases to an equality with the second.

4. In such short lines it is therefore imperative that the observation be so arranged that we may distinguish between the terrestrial and the ground-plate current, and this is easily done by making different combinations of the four plates by means of the four connecting cables.

5. For plates 1 meter square and 1 kilometer apart the resistance of the earth may be estimated at from 30 to 60 ohms; if, therefore, the resistance of the cable and that of the galvanometer coil be each about 40 ohms, so that the total resistance of plate and wire be about 100 ohms, then a galvanometer must have a sensitiveness of 0.000002 ampere for one division of the scale in order that the deviations in times of great magnetic perturbations shall not frequently exceed the limits of the scale, supposing the latter to be 250 divisions long, corresponding to 0.05 volt.

6. The ratio of the strength of the earth current in any conductor to the strength of the ground-plate current is independent of the resistance of the conductor and of the size of the earth plate, but increases with the distance between the latter; therefore an increase in the size of the ground plates, or the introduction of resistance in the conductor, do not tend to weaken the ground-plate current in comparison with the terrestrial current.

7. If we desire to observe the terrestrial current during magnetic calms, the distance between the plates must be at least 50 kilometers; for shorter lines, say from 1 to 5 kilometers, the terrestrial current cannot be satisfactorily observed unless the ground plates are much more nearly alike than ordinarily attained. (*Z. O. G. M.*, XIX, p. 55.)

352. H. Wild, from a further study of observations made up to September, 1883, draws the following conclusions:

1. The earth current appears not like a current of nearly uniform intensity, but as alternating stronger and weaker currents, which rapidly change their direction in space.

2. The east-to-west components are stronger than the north-and-south component, or the direction of the current is nearer the parallels than the meridians.

3. Only by taking the mean of the twenty-four term days during the year do we find traces of slight diurnal change whose amplitude corresponds nearly to 0.0008 volt. The diurnal change of the earth current is therefore not the cause of the diurnal change in the magnetic elements.

4. As soon as the earth currents in both lines become strong, the magnetic instruments deviate from their ordinary positions, and these perturbations increase with the strength of the earth currents, but not in any regular proportion.

5. The changes in the south-to-north line preceded by about five minutes the changes in variation of declination, and similarly the current in the east-to-west line preceded the changes in the horizontal intensity, so that the earth current would appear as the primary cause. He concludes that the earth currents are the primary cause of many perturbations, but not the cause of the periodic variations in the magnetic elements. (*Z. O. M. G.*, XIX, p. 510.)

353. Prof. K. Schering, of Göttingen, criticising Professor Wild's results, states that the method is not thoroughly reliable, and expresses his conviction that we cannot determine a difference of potential between two points of the earth, nor even prove its existence, if we use ground plates which by contact with the earth become electrified in any unknown manner. He recommends the method introduced by W. Siemens in the programme of the German North Polar expedition for 1882–'83 as the only one to be used in determining the currents induced by the changes taking place in the magnetic force of the earth. (*Z. O. G. M.*, XIX, p. 552.)

354. The great magnetic storm and auroral display of November 17, 1882, is abundantly discussed, with numerous contributions of observations, throughout vols. XXVII and XXVIII of *Nature.*

355. T. W. Backhouse, of Sunderland, collects together all accessible observations on the spectrum of the aurora, and shows that the number of striking coincidences between it and the modified air spectrum make the suggestion that they are identical one worthy of consideration. (*Nature*, XXVIII, p. 209.)

356. O. Jesse discusses the auroral arc observed October 2, 1882, and places it at an altitude of 122.2 kilometers, with a probable error of 4.5 kilometers. (*Z. O. G. M.*, XVIII, p. 238.)

357. O. Jesse, in some remarks on the determination of the altitude and position of the aurora, states that the very rapid changes going on during a display make it important to have a method of determining its altitude by observations made at one place. He has, therefore, developed such a method, which is published in full in the Astronomische Nachrichten, No. 2540. This method is based upon the assumption that the rays constituting the aurora lie on the surface of a cone whose apex is in the interior of the earth, where the direction of any one ray and the osculating magnetic axis of the earth intersect each other. The application of this method requires that we should measure for as many rays as possible the angle under which the ray or its prolongation intersects the horizon; also, the azimuth of the point in which the ray cuts the horizon, together with an accurate determination of the time; furthermore, for some of the rays the apparent position of their highest exten-

sion is to be determined. For these observations he proposes a binocular attached to a circle having a horizontal axis which revolves around a vertical axis, so that the binocular can have the plane of its axes brought into the plane of the auroral beams. Many observations show that the auroral rays arrange themselves pre-eminently along the magnetic parallels in curves that cut the magnetic meridians at right angles; they also show that the auroral phenomena as arranged along the magnetic parallels follow the curves of equal total magnetic intensity. (*Z. O. G. M.*, XIX, p. 405.)

358. Dr. H. Ekama, of Haarlem, gives a summary of the observations on the aurora made by the International Polar party sent by the government of the Netherlands to the Sea of Kara. The aurora was in general very unsteady and variable, so that drawings could rarely be made. Arcs frequently occurred, but soon changed to the form of bands; the dark band below the arc was never distinctly seen. The aurora was invariably visible when the heavens were clear and the moon not too bright; the finest appearances occurred at about 10.30 P. M., when the corona most frequently occurred; the bands were strongest about 9.30 P. M. The auroras were generally on the north side of the heavens, and only reached to the south of the zenith after a very bright display; the highest point of the arcs did not lie in the magnetic gradient, but in the astronomical meridian. Out of 86 observed arcs and 66 bands the summits of 64 and 41, respectively, lay in the astronomical meridian. Ekama has computed the altitude of his auroras by the formula given by Nordenskiold in his account of the Vega's wintering in Behring's Sound, 1878–'79; the results of nine nights agree closely, and give for the distance of the arc above the earth's surface 0.033 of the earth's radius; for the radius of the nearly horizontal arc itself 0.034; and for the distance of the center of this circle below the earth's surface 0.02 of the earth's radius, which value agrees with that of Nordenskiold. The auroras were generally very faint; the arcs had no color. The wave length of the peculiar auroral line was determined by the spectroscope at 556.53 millionths of a millimeter; no other lines were visible; even a wholly red aurora gave only this yellow-green line. No connection was found between the polar bands of clouds and the auroral light. Out of 203 polar bands the vanishing or converging points were distributed as follows:

Trend of vanishing points.	No. of cases.	Trend of vanishing points.	No. of cases.
W.-E.	22	N.-S.	24
WN.-ESE	12	NNE.-SSW.	27
NW.-SE	22	NE.-SW.	75
NNW.-SSE.	12	ENE.-WSW.	9

The direction of the polar bands probably depends on the direction of the wind prevailing at the cloud level. (*Z. O. G. M.*, XIX, p. 482.)

359. A. Paulsen, of Copenhagen, gives in *Nature*, XXIX, p. 337, the results of observation on the height of the aurora as made at Godthaab, of which the following notice appears in the Austrian *Zeitschrift für Meteorologie:*

The results of observations at that station on the altitude of auroras were as follows:

Number of cases.	Altitude.	Number of cases.	Altitude.
	Kilometers.		*Kilometers.*
1	68.8	1	20 to 30
2	50 to 60	1	10 to 20
2	40 to 50	14	0 to 10
1	30 to 40		

Of the latter 14 cases the lowest were, respectively, 3.72, 3.69, 3.22, 2.87, 1.99, 1.96, 1.35, 0.61.

360. Prof. H. Fritz, of Zurich, states that as these observations were very carefully made, the distance between the two observers being 5.8 kilometers, they seem especially worthy of study, and undoubtedly confirm the observations of S. Fritz, made at Ivigtut, and those of Steenstrup, made in Iceland, and assure us that undoubtedly the auroral light may exist even at the ground. He has therefore at once collated all previous records of low-lying auroras, and makes some general remarks upon the present state of our knowledge with regard to these and the character of the observations still needed to further elucidate the subject. (*Z. O. G. M.*, XIX, p. 290.)

361. Prof. H. Fritz, in a general review of Tromholt's Nordlysets Perioder and of Rubenson's Catalogue of Swedish Auroras, finds that the 111-year period, first determined by him in 1862 and confirmed by Loomis for the American auroras, is also strongly confirmed by Rubenson's catalogue. He also finds that the influence of the bright light of the moon in introducing an apparent lunar period, as first shown by him in 1864, is fully confirmed by Tromholt from the study of observations at Godthaab and Christiania. (*Z. O. G. M.*, XVIII, p. 321.)

362. Prof. Sophus Tromholt, in his "Om Nordlysets Perioder," published by the Institut Mét. Danois, deduces the following conclusions from the observations of the aurora made at Godthaab, in Greenland, during 1865 to 1880 by Professor Kleinschmidt:

1. Everything pertaining to the variable frequency of auroras in Godthaab proves that the phenomenon exists there under quite different conditions from those obtaining in lower latitudes.

2. The number of observed auroras is inversely proportional to the square root of the cloudiness.

3. After correcting for cloudiness there remains not only no parallelism between the sun-spots and the auroras, but even an almost diametrical difference as to frequency.

4. The maximum of auroras is delayed two years behind the minimum

of sun-spots, but the next following auroral minimum coincides with the sun-spot maximum.

5. Some observations by Bloch, 1841 to 1846, show that the number of auroras is very large at the minimum of sun-spots, but decreases as the sun-spots increase.

6. By separating the evening and morning auroras he finds the former twice as numerous as the latter, and that it is probable that the evening auroras give us the best idea of the true condition of the atmosphere with reference to these phenomena.

7. The morning and evening auroras both show a maximum in the polar region at the time of the winter solstice.

8. Kleinschmidt distinguishes eight types of auroras, three stationary, and five of them movable. Of these the most interesting is his type number 7, namely, rays arranged in a band stretching from the northeast to the southwest and passing through the zenith. This phenomenon rises in the east like a column of fire from some point in the interior of Greenland. The column is narrowest and brightest over the land, while its southwestern extremity, namely, over the sea, is slightly broader and fainter, so that in general it does not seem to touch the southwest horizon. These arches almost always take the same position. [This form of arch, which is comparatively rare in Europe, is much more frequent in the United States and Canada. An attempt to locate several such arches and to explain their structure will be found in the report of the Chief Signal Officer for 1876.]

9. The aurora very rarely appears to the north of Godthaab, the center of the phenomenon is most frequently between the south and south-southeast, and this holds good for the whole of the west coast of Greenland.

10. The color of an aurora is almost invariably white, except only a little red or green during the most rapid movements; not the slightest noise has ever been heard.

11. With reference to the oscillation north and south of the zone of greatest auroral frequency, Tromholt finds that the relative frequency of auroras which occur in the zenith or to the north of the observer has an annual period showing two minima at the equinoxes and a maximum at the winter solstice.

12. In every month he finds that the morning auroras are more frequent in the zenith and the north than in the south, and that the reverse holds good for the evening auroras.

13. As regards the auroras in the daytime, his figures confirm Weyprecht's conclusion that, in the neighborhood of the autumn equinox, the auroral zone stretches toward the south and then turns toward the north to reach its northernmost position at the winter solstice, it then returns southward and has its southernmost position at the spring equinox.

14. In the course of twenty-four hours the auroral zone moves north-

ward during the night and southward during the day. This explains at once the daily period which is especially marked in middle latitudes where the maximum frequency of auroras occurs some hours before midnight.

15. At the time of the aurora maximum the frequency at Godthaab exceeds not only the absolute but also the relative frequency for the zenith for this locality, or others more to the north of it; a similar statement is true for the time of minimum. Therefore, in the course of the eleven-year period, there is a periodic movement of the auroral zone which lies further north during the sun-spot minimum than during the maximum.

16. We see thus that a perfect harmony exists between the eleven-year period and the annual and diurnal periodicity, so that these three periods have one and the same cause, namely, the oscillation of the auroral zone.

17. Considering each of Kleinschmidt's seven types separately, Tromholt finds that during the auroral maximum not only the frequency, extent, and intensity, but also the variety of kinds surpasses those of the minimum.

18. Between the periodicity of the cirrus clouds and that of the aurora a connection exists, such that these phenomena have their maxima and minima almost at the same time.

Tromholt concludes that we are not able to establish a satisfactory theory as to the nature and cause of the aurora, but that it is not a cosmic phenomenon is shown by the want of agreement in the auroral periods for the whole earth. For the present, therefore, observations are of the first importance. He has organized a network of observers for Scandinavia, Finland, Denmark, England, and Iceland, and has already shown that over so small a region as Norway no day passes without an aurora at one or more points. (*Z. O. G. M.*, XVIII, p. 306.)

363. Prof. S. Lemström, of Helsingfors, gives the results of his own observations on artificial auroras at Oratunturi and Sodankyla and Pietarintunturi. (*Nature*, XXVIII, p. 60.)

364. Prof. S. Tromholt communicates a general account of his latest researches, during 1882 and 1883, into the aurora and its phenomena in Northern Finmark, where the aurora is seen almost every night in numerous forms and frequently very low down, although his own estimate of its height is 150 kilometers. (*Nature*, XXVII, p. 394.)

365. After concluding his special observations in Kautokeino, Norway, Tromholt took up his residence in Redykjavik, Iceland, in October, 1883, and communicates to *Nature* some of the results of his work during the winter 1883–'84. He has never as yet seen any auroral light descend to the low level of the mountain top of Esja, namely, about 2,500 feet. The weather, however, has been very unfavorable, and he has made but 40 observations on 83 thoroughly clear evenings; apparently Ice-

land lies, at least for this year, south of the position of the maximum zone. (*Nature*, XXIX, pp. 226, 343, 409, and 537.)

366. On page 80, vol. XXX, of *Nature*, Tromholt states that a few lovely days have enabled him to set up his artificial-aurora apparatus on the summit of Esja, but without as yet any optical results.

367. In the autumn of 1884, Prof. Tromholt returned to Bergen where he will work on the great catalogùe of auroras observed in Northern Europe, which with other works is being prosecuted at the expense of the Norwegian government. (*Nature*, XXX, p. 592.)

XI.—(*a*) REFRACTION AND MIRAGE: (*b*) SCINTILLATION; (*c*) SPECTROSCOPY AND PHOTOSPECTROSCOPY; PHOSPHORESCENCE, ETC. (*d*) HALOS; RAINBOWS; (*e*) PHOTOMETRY; COLOROMETRY; TWILIGHT, ETC.

368. T. von Oppolzer, of Vienna, at a meeting of welcome in honor of the session of the International Polar Commission April 21, 1884, delivered an address upon the connection between atmospheric refraction and the distribution of temperature throughout the air. After explaining his formula for refraction, based on the assumption that the change of temperature with altitude is proportioned to the change of density of the air, and having shown that this empirical assumption agrees with the observations at least for the lowest 10 kilometers, he says that it may now be asked whether the observed atmospheric refraction may not give some clue to the actual temperatures at great heights in the air where direct observations can never hope to reach. This, however, he answers in the negative, but, in regard to the lower strata, it is entirely possible for meteorology to derive assistance from astronomical observations, though the latter will undoubtedly receive much more assistance from the former. This essay is printed as an appendix to the Zeitschrift of the Austrian Association for May, 1884. (*Z. O. G. M.*, XIX, p. 265.)

369. P. G. Tait gives a thorough elucidation of the atmospheric condition necessary to produce forms of mirage. This is in continuation of his former paper on mirage, and as an example of an application of Hamilton's general method in optics, which is being published by the Royal Society of Edinburgh. (*Nature*, XXVIII, p. 84.)

370. C. Montigny has for some time observed the colors of the stars by means of a scintillometer, and among other things has discovered that the blue color prevails remarkably when rain approaches, and this phenomenon can therefore be used for the prediction of rain. In June, 1883, having observed that the blue color had been absent for three months, and that the green was becoming more prominent, Montigny ventured the prediction that the quantity of water in the upper strata of air had become diminished, and that during the year 1883 fewer long rains would occur. This prediction having been well fulfilled, Montigny, in April, 1884, made the same observations and renewed the same pre-

diction for this year; in fact, he had observed that the blue was even less prominent than in 1883, that the green was more prominent, and that even violet occasionally occurred. Montigny suggests that the blue tint in the scintillation is due to the water in the atmosphere, which is known to have a bluish tint when viewed by ordinary sunlight. (*Z. O. G. M.*, XIX, p. 534.)

371. L. Thollon contributes to the Bulletin Astronomique an elaborate study into the structure and origin of the lines forming the group B of the solar spectrum, which paper is handsomely reproduced in *Nature*, XXX, p. 520. This region was carefully worked over by Piazzi Smyth, and Langley; but Thollon has now revised his own previous work, and the elegant map given by him shows at a glance, first, the metallic lines; second, those produced by atmospheric vapors—probably the aqueous vapors; third, those produced by atmospheric gases—oxygen, nitrogen, carbonic acid, and any others that do not materially vary in quantity, leaving finally non-telluric lines, twenty-five in all, or seventeen if we count double and triple lines as one. The lines due to atmospheric gases constitute a system of twelve pairs, and the whole group is distinguished by its regular symmetry. Under such a scrutiny as this there seems no doubt that certain lines are also a perfect indication of the hygrometric state of the air. In 1882 Professor Egoroff, of Warsaw, joined Thollon in his investigations at Paris, where they examined the spectrum of a beam of electric light 10 kilometers long, and which gave a perfect reproduction of the telluric rays; afterwards, by condensing oxygen in a short tube, the gaseous rays were obtained for the groups A and B, and probably a greater quantity of oxygen would have given the feebler group Alpha; so that these three groups, A, B, and Alpha, originate in the absorption of atmospheric oxygen. That the spectrum of absorption for cold oxygen should differ so much from the spectrum of emission for incandescent oxygen is, he thinks, attributable to the influence of heat. Thollon is at present engaged in the further search for lines or groups due to the presence of nitrogen or carbonic oxide. Hitherto, apart from the oxygen, or A, B, and Alpha groups, he has discovered no lines that may be confidently attributed to the constant gaseous portions of the atmosphere. (*Nature*, XXX, p. 520.)

372. G. Pizzighelli publishes, through Dr. E. Hornig, a work on Actinometry, or the photometry of the chemically active radiations. The author is a most expert photographer, and has here compiled an almost exhaustive account of modern apparatus and methods for measuring the intensity of light by photographic and chemical methods. He gives a special chapter to the meteorological applications of actinometry, especially the results of the studies of Pernter, published in 1882. (*D. M. Z.*, I, p. 420.)

373. Captain Abney, as the result of photographing the ultra-red portion of the solar spectrum in very various atmospheric conditions, found that in very dry weather the photographs show only absorption

lines, but in very moist weather they show strong absoption bands, which are more numerous and darker as the relative humidity of the air is greater. These demonstrate that this absorption is not due to the true aqueous vapor in the air, but to water in a fluid condition, namely, minute fog or cloud particles. He also concludes that it is certainly water in this fluid condition that causes the deep blue of the sky, since no other ground can be imagined why the color should be a deeper blue in moister weather; this view is also confirmed by the fact that in ascending high mountains the tint changes from a dark to a black blue. (*Z. O. G. M.*, XVIII, p. 276.)

374. Captain Abney and Colonel Festing have presented a valuable paper on the influence of water in the atmosphere on the solar spectrum. They both recognize the fact that the spectrum extends to the lower limit established by Langley; they then investigate the radiation from the positive pole of the electric arc, and introduce absorbing layers of water. These so modify the original curve of distribution of heat in the spectrum that even the introduction of an absorbing layer of water $1\frac{1}{8}$ of inch thick reduces it to similarity with the curve given by sunlight, whence they conclude that the greater part of the absorption in the red and ultra red portions of the solar spectrum is due to the presence of water. As opposed to Langley's opinion that the maximum intensity of the solar spectrum outside of the earth's atmosphere lies nearer the blue, their own observations give an extra-atmospheric curve having a second maximum in the ultra-red. This they explain as due to the superposition of radiations belonging to a low temperature upon radiations from bodies with a high temperature, the former being the prevalent. By examples they show that the superposition of such curves from different sources of heat will give such a result. Assuming with Dewar that the areas of these radiation curves are proportional to the temperatures of the radiating bodies, they find the temperature of the sun's surface to be between 10,000 and 12,000 degrees. (*Z. O. G. M.*, XIX, 430, and *Nature*, XXVIII, p. 45.)

375. H. Becquerel has studied the same question by means of the phenomena of phosphorescence. He has investigated under different atmospheric conditions the ultra-red part of the spectrum, and, like Captain Abney, found that the absorption lines increase with the relative humidity. He also found that the absorption bands of layers of fluid water agreed for various thicknesses of water with the above lines for corresponding relative humidities. (*Z. O. G. M.*, XVIII, p. 277.)

376. Cornu proposes to determine the absorption of the solar rays by observing the intensity of well determined atmospheric lines in the solar spectrum, which he accomplishes by comparing them with the constant lines that certainly owe their existence to the absorption in the solar atmosphere. This is an extension of the proposition to observe the rain band so earnestly advocated by Piazzi Smyth. Cornu chooses that portion of the spectrum between the wave length 587.40 and 602.90,

and assigns to the various groups of atmospheric lines corresponding metallic lines for comparison. (*Z. O. G. M.*, XVIII, p. 239.)

377. Dr. H. Klein, in reference to the use of the spectroscope, or the observation of the so-called rain band, states that his own observations confirm those of Smyth, Capron, and others to the effect that a prominent rain band is regularly followed in a short time by precipitation. However, the frequent exceptions to this rule renders the spectroscope alone very unreliable; this is to be attributed to the fact that the spectroscope makes no distinction between the moisture near by and that at a great distance. When from his observatory Klein examines the horizon at an altitude of 20°, he finds the vapor lines on the east, southeast, and northeast notably darker and more prominent than in any other direction; this he attributes to the fact that a few thousand feet distant on the east flows the broad Rhine; but he states that this increase of the vapor line does not always occur, and at certain times the influence of the Rhine is not to be noticed; he has as yet found no explanation for these exceptional cases. The application of the spectroscope to the prediction of rain is, he thinks, problematic, except in the case of heavy thunder storms for which it frequently gives good indications. Upton's comparison showed that 69 per cent. of rain predictions were verified within twenty-four hours when based entirely upon the intensity of the rain band, but 84 per cent. were verified when other meteorological conditions were taken into account. The spectroscope has been used at the Wetterwarte of the Cologne *Zeitung* with satisfactory results in summer. (*Z. O. G. M.*, XIX, p. 531.)

378. Mr. W. Ackroyd has read before the Physical Society of London a mathematical investigation of the rainbows produced by light before entering the rain drops. (*Nature*, XXVII, p. 133.)

379. The observation of coronas and fogbows, made at the summit of Ben Nevis, promises to give us valuable information in regard to the size and shape of the particles composing the clouds; thus, October 4, 1884, strong double corona surrounded the moon; outer diameter of the red circle was for the outer corona 7° 46′, and for the inner corona 4° 52′. When clouds came between the moon and observer three such rings were seen, the measurements of which gave for the inner ring 4° 6′, middle 6° 2′, outer 8° 10′, the probable error in each ring being about 8′. A colorless pair of fogbows visible on a distant fog bank gave diameters of 75° for the outer ring, 65° for the inner and fainter ring; the space between the ring appeared quite dark and no color could be distinguished. (*Nature*, XXX, p. 613.)

380. Professor von Bezold, in the publications of the International Polar Commission, described the normal phenomena of twilight as follows:

1. A bright segment appears on that side of the sky below whose horizon the sun is found; this is limited at the top by a special bright

zone, above which the ordinary blue or purple sky is visible, while below we have yellow, then orange, and on the horizon brownish red.

2. Opposite to the above is a dark segment which is simply the ashy-tinted shadow of the earth, and which is sharply distinguished from the remaining portion of the heavens.

3. A circular region of considerable diameter of a rosy-red that is generally described as the purple light; this develops above the bright segment a long time before sunrise or after sunset, so that the lower part of this region seems to be hidden behind the bright segment. The center of this region sinks rapidly after sunset, while at the same time its radius increases so that finally the limit of the borders of the purple region unites with that of the bright segment, the impression being as if the purple light slipped in behind the bright segment. The purple light plays the part of a very much magnified, very much diluted, image of the sun; at the time of its greatest development the general brightness is increased so that objects on the earth's surface that were invisible soon after sunset become again visible. The maximum of this second illumination occurs in the Alps when the sun is four or five degrees below the horizon, at which time the center of the purple light is about 18° above the horizon, while its highest point reaches up to 40° or 50°.

As soon as the purple light has completely disappeared behind the bright segment there appears a second dark segment on the opposite side of the sky. Soon there further develops a second bright segment above the slowly sinking first one, and only with difficulty distinguished therefrom; with very clear skies one can later occasionally also observe a second purple light, and therewith a temporary increase of brightness, so that a third illumination of objects favorably located can be observed. [It would seem that the occurrence of two separate periods of the red or rosy or purple tint, as was observed in the winter of 1883–'84 at many places throughout the world, is therefore simply an unusual development of an ordinary phenomenon. The twilight phenomena of 1883–'84 have been specially due to the remarkable development of the second purple light, which has frequently surpassed the first purple light.] (*D. M. Z.*, I, p. 32.)

381. Dr. G. Hellmann contributes some observations on twilight made by himself in Spain, 1875 to 1877, and follows this by a comparison with previous authorities, from all of which he deduces the following results:

1. The depression of the sun under the horizon at the end of the astronomical twilight is not, as has been generally assumed, constant at about 18 degrees.

2. The depression shows a decided annual period, a maximum in winter and minimum in summer.

3. The depression is greater in the morning than in the evening.

4. It shows an intimate connection with the relative humidity of the

air, increasing and diminishing directly with it, so that the items 2 and 3 are probably explicable thereby.

5. It follows that this angle (whose annual mean value for the evening twilight is in Athens $15^{\circ}.9$, southern Spain $15^{\circ}.6$, South Atlantic Ocean $15^{\circ}.6$) must be greater in high latitudes than in low, and on the ocean than in dry continental regions, but this conclusion needs further confirmation by other observations.

6. Since the twilight depression of the sun is thus periodically variable it follows that the various solutions of the problem of the shortest twilight thus far offered are no longer sufficient. (*Z. O. G. M.*, XIX, p. 57.)

382. Dr. G. Hellmann, in a second communication on the twilight phenomena, analyses numerous observations from all parts of the world and formulates the following conclusions relative to the difference between this phenomenon in southern Spain and in Germany.

1. The phases of the phenomenon are better developed in Spain than in Germany, the chronological order is more determined, the strata of different colors are easier to distinguish from each other, the limit of the bright segment against the dark sky is very sharp.

2. In Germany the extension of the colors in time and space are greater than in Spain, except for the anti-twilight.

3. In reference to the colors, green was almost regularly observed in all its shades in Spain but rarely in Germany.

4. The red colors of the twilight in Spain had in Germany very frequently a decidedly flesh color and purple tint.

5. Violent colors in Germany were more decided than in Spain.

6. In Spain there was a greater contrast between the twilight phenomenon of the summer and winter (the dry and rainy periods) than in Germany.

The above conclusions, and in fact this whole essay, were completed before the appearance of the remarkable sky colors of 1883–'84, and in reference to these Hellman states in a note that, although he has followed it closely and collected numerous reports from others, yet he will not at present attempt any analysis or explanation. He however notes the great ignorance of observers generally as to what constitutes the ordinary and typical phenomena of the twilight, and at present his own feeling is that the real peculiarity of the phenomena of 1883–'84 consisted in their universality, the length of duration, the intensity and variety of colors. (*Z. O. G. M.*, XIX, p. 162.)

383. Professor Kiessling, of Hamburg, has reproduced the experiments of Coulier, Mascart, and Aitken on the effect of dust in the atmosphere. He says that if we understand the word dust to refer to the total of all foreign substances in the atmosphere, including coarse and fine particles of dust, microscopic or organic forms, the products of putrefaction and oxidation, even when they are entirely gaseous, as, for instance, the expirations of human beings and animals, there will be

found a definite very small quantity of dust which is especially favorable for the development of color by the process of diffraction, and this can therefore be specified as the dust favorable to optical phenomena.

2. The absolute maximum of color due to diffraction is in moist air conditional upon the simultaneous occurrence of this optical dust with the maximum relative humidity of the air stratum in which it is contained.

3. The twilight colors depend principally upon diffraction in moist air. (*D. M. Z.*, I, p. 34.)

384. Professor Kiessling, of Hamburg, has collected together the observations of others and compared them with his own observations on the influence of artificial fog on direct sunlight, and the consequent explanation of the twilight phenomena. He uses a glass vessel with several apertures in connection with a Sprengel or water air pump; within this vessel he forms fogs of varying degrees of intensity, and examines the diffraction phenomena when a beam of sunlight falls upon the fog from the heliostat. Besides the fog from aqueous vapor, he also utilizes the sulphate of ammonia, phosphoric acid, gunpowder, and other substances producing very dense smoke or fog; for instance, with sulphate of ammonia a very dense smoke is produced consisting of exceedingly small hard particles of this salt; after twenty or thirty minutes of settling a thick white dust covers the base and sides of the vessel. The sun, seen through the cloud, does not blind the eye, but shows a remarkable change of colors. At the first moment of its formation the sun appears of a brilliant dark copper color, but changes its color rapidly, first to a violet tint and then through dark carmine red into a brilliant azure blue. This change of colors occupies in dry air about two minutes, but in moist air scarcely twenty seconds; similar phenomena take place with other heavy vapors. If the light is allowed to fall upon a white screen it is seen to be at first of a copper-brown, which afterward becomes blue. If in place of these chemical dust-clouds we allow a stream of aqueous vapor to escape from a steam boiler, the cloud of fog shows an intense blue as soon as the above beam of blue solar light falls upon it; if the stream of vapor is, however, properly managed, it can be made to exhibit in itself all the changes from brownish red to blue, which, however, very rapidly disappear on account of the dissipation of the cloud. In order to accomplish this best the stream of steam must be horizontal and mixed with a feeble current of very cold air drawn over ice. It has not yet been possible to Kiessling to experimentally reproduce the green colors of the sun.

If the vessel within which the diffraction phenomena are produced is full of moist, perfectly filtered air, entirely free from dust, then a fog can be produced by simply lowering the temperature, which is, however, only visible in direct sunlight. This fog consists of very small, scattered, rapidly moving particles of vapor, which, however, in transmitted light show not the slightest trace of colored diffraction rings, evidently

because there are too few of them. This fog renders it very doubtful if the law announced by Aitken in 1879 can be true, according to which aqueous vapor will not condense from the air without having a solid nucleus of dust particles on which to accumulate. If into the vessel full of filtered air a small stream of steam enters, then the first cloud formation of fine fog soon disappears, but after a few minutes large scattered rain drops strike on the surface of the inclosure, and form a rain without fog or cloud. But if we allow a very small quantity of dusty air to enter the vessel, then immediately fine fog is formed along side of the larger rain drops. If the beam of sunlight falls upon this mixture of rain and fog, then a yellow halo with reddish brown borders is formed of the same color and magnitude as with ordinary lunar halos. If now by lowering the pressure we produce a sudden fall in temperature, there is formed a system of larger fog particles and a corresponding system of larger diffraction rings without changing those already formed. In order to realize a fine mist or fog or haze of particles having a very uniform size we must evidently have the maximum quantity of moisture in the vessel, or the most favorable mist and the most perfect saturation. This is best attained by introducing quite warm moist air and lowering the temperature rather slowly. In this way we obtain a very intense development of color, and the amplitude of the diffraction circle varies between 10° and 30° depending upon the size of the particles while the intensity of the color depends upon the uniformity of their size. By further diminution of pressure and consequent cooling and increase in the size of the particles remarkable changes in color take place; the variations in the colors depend in a very sensitive way upon the degree of saturation and the rapidity of cooling. In this way Kiessling has been able to re-produce so large a number of the appearances observed in nature that there can scarcely be any doubt but that the diffraction due to particles of aqueous vapor will be found to explain nearly all our sky colors. (*D. M. Z.*, I, p. 117.)

385. Dr. von Danckelman has published an extensive memoir collating the meteorological observations made on the coast of southwest Africa, and especially at Vivi on the Lower Congo. A summary of his results with regard to the cloudiness is given by him in *D. M. Z.*, I, p. 301.

Von Danckelman calls attention to the fact that the great forest and prairie fires of the Congo in central Africa throw up into the atmosphere such an enormous amount of fine dust, that we have here a source of production of fine particles that annually throws great quantities into our atmosphere—quite as much or vastly more than could have come from the Krakatoa eruption. (*D. M. Z.*, I, p. 311.)

386. [The corresponding prairie and forest fires in America, giving rise to our Indian summer haze, have long been known to produce a copper-red tint in the sky and over the solar disk. This haze however has rarely been known to spread far eastward over the Atlantic, and

certainly never around the world, and to all latitudes from 60 north to 40 south; neither does it ever give rise to anything like the brilliant purple twilight. The great cloud of smoke due to the forest fires of 1871 (not to the Chicago fire as erroneously assumed) was observed by navigators in the mid Atlantic. The haze is in fact composed of minute particles of carbon, each of which, as is well known, has the property of condensing upon itself a small atmosphere of other gases, including aqueous vapor. This quasi-chemical action seems to hold the vapor in an invisible state at a lower temperature than would have been the case were no particles there; it hinders condensation so that rain and cloud are lessened during the prevalence of this smoke. When however rain does form, it falls with unusual severity. It is, we think, likely that to this property of carbon or to the special radiating and cooling properties of fine solid particles that we must attribute the phenomena discussed by Aitken, as there can be no doubt that aqueous vapor will condense into fog particles and larger drops even in an atmosphere free from fog and solid particles.]

387. [The remarkable red sunsets and sunrises of October to December, 1883, have formed the subject of innumerable contributions both from an observational and theoretical standpoint. Exhaustive investigations are promised by committees of societies, especially the Royal Society, which have undertaken to collect all the data relative to these important phenomena. The hypothesis that these were due to the gradual spread over the northern hemisphere of dust ejected from the tremendous eruption of Krakatoa, started by Bishop, September 5, 1883, and Lockyer, October, 1883, was first modified into the assumption that moisture as well as, or even instead of, dust was more plausible; the possibility being granted that the vapor exists in the form of minutest spiculæ of ice or of minute spheres. Subsequently it became a query whether circumstances favorable to the dissemination of ice spiculæ or vapor in the higher regions might not have existed independent of the Krakatoa eruption; this view was then strengthened by the discovery that similar twilight phenomena had been observed some time before the Krakatoa eruption, while on the other hand it was also shown that several volcanic eruptions in past years had been followed by similar sky colors. The renewal of the phenomena in 1884 made it highly probable that we have to seek the cause of these colors in something outside of the earth's atmosphere; during a whole year the sun had been surrounded by a large irregular cloud of haze, extending 20 to 40 degrees from its center in all directions. This haze was decidedly streaky or striated, and occasionally showed a pinkish tint. At present the most plausible hypothesis seems to be that the earth in the autumn of 1883, and again of 1884, passed through a stream of gaseous or vaporous meteoric matter, which temporarily combined with the earth's atmosphere, while the great mass passed on to the sun, and has accumulated as a nebulous cloud about that body. The color phenomena,

as seen in our atmosphere, are most plausibly due to selective absorption and reflection from minute solid particles, whose size is comparable with the dimensions of the wave length of light. That these should exercise also a selective influence upon the ultra-red rays, such as would be detected by Langley's bolometer, seems highly probable. It is therefore possible that the general distribution of heat over the earth's surface may have been slightly affected by the novel addition to our atmosphere, and especially may have had some influence upon the formation of rain and snow; but these influences must have been quite feeble, and have not yet been demonstrated from observations. On several occasions during the past century the earth has passed near enough to comets or their tails to awaken inquiry as to the possible result of actual contact; in fact, in the summer of 1876, the earth may possibly have encountered the tail of the comet then visible, as several observers reported the appearance of pinkish and ashen tints in the sky. It would not be surprising if we should sometime be able to show that these sky and sunset phenomena, as well as the aurora, and possibly other matters, such as Wilkes's red fog, may be due to the encounter of cosmic meteoric matter by the earth in its annual orbit.]

388. Dr. Neumayer publishes a large collection of data relative to the twilight and other phenomena, in a series of papers extending through the first volume of the Journal of the German Meteorological Society.

389. Prof. H. Krone, of Dresden, communicated through Dr. Neumayer his observations and conclusions as to the nature of the twilight phenomena.

1. A fine haze that cannot be called a fog and that does not diminish the brightness of the sunshine must be the origin, and has been present ever since the last of August.

2. The twilight colors were tested by the use of a number of colored glasses, which showed that the orange was absorbed by the blue, while the red was not; the red region agreed with the ring observed by Falb. This ring he considers due, not to diffraction, but that it is the red region of the rays of less refrangibility, like the reddish, yellow and red caused by the ordinary refraction at sunrise or sunset, and due to the air and its vapor.

3. A variation appeared on the evening of January 2, shortly after the outburst of the orange, as an intense rosy red bundle of rays, which in a few minutes extended from the sun, then under the horizon, in all directions through the red region nearly up to the zenith, and sideways for 70° in the horizon either side of the sun. Similar phenomena were seen by Krone during his journey to India in 1875, and both appearances then and now indicated that the sun's rays were passing between clouds in our atmosphere beyond the horizon and through a stratum of air containing more aqueous vapor, which communicated to them a rosy red tint.

4. It is not to be denied that the phenomena in general are due to the refraction of the sun's rays in the aqueous vapor of the atmosphere; but in order to explain the superposition of color we must also consider the reflection of colored rays from exceedingly small bodies at an extraordinary height in the atmosphere. This does not constitute interference phenomena. [It has been called, very appropriately, selective reflection.]

5. The ordinary twilight is, to a certain extent, such a phenomenon of reflection; the astronomical twilight disappears at the horizon when the sun is about 18° below that plane from which we compute the altitude of the layer of haze producing it; but if the duration of twilight increases we must conclude that the layer of haze is proportionately higher. Krone's observations, however, in December, 1883, and January, 1884, seem to show that occasionally the twilight did not disappear through the whole night, but that a reddish tint was visible in the horizon and even half way to the zenith. That this reflecting material can possibly be the finest dust from the volcanic eruption at Krakatoa, is, he thinks, entirely improbable; neither can it be due to the presence of ice spiculæ, but it must be minute particles of water. Owing to the low temperature in the upper regions, this water can only be frozen, but we know nothing as yet as to the form of the particles of such very cold aqueous vapor. (*D. M. Z.*, I, p. 277.)

390. [The examination of certain thin hazy clouds that covered Paris during January, 1882, was made by Fonvielle, who rose up into them in his balloon, and found that they were formed of the minutest spheres of water frozen at a temperature many degrees below freezing; the formation of the cloud was apparently due to radiation, as it stayed in the same locality for several weeks. The atoms of water were quiescent, but if set in motion among themselves crystallized into minute spiculæ. Dufour has shown that minute drops may be cooled to —20° C., so long as the surface tension is kept large without crystallizing or even solidifying; it is therefore plausible that the twilight phenomena of 1883–'84 were due to selective reflection and diffraction by aqueous spherules of the finest size, such as must always exist to a greater or less extent in the upper atmosphere. If the particles, whether dust or vapor, were electrified before or while being carried up to the height of several miles, they would in the thin air of that region not only be carried along by its currents, but by their own mutual repulsion would tend to rise still higher, forming an appendage to the earth, and reminding one of the ascent of an envelope from the surface of the nucleus of a comet, where the particles are distinctly seen to ascend on the hot side toward the sun and then by mutual repulsion, as shown by G. P. Bond and other astronomers, flow away from the sun.]

391. Among the principal items relating to the sunsets and Krakatoa, we may mention the following:

Lockyer's theory of the volcanic dust. (*Nature*, XXIX, pp. 148–174.)

Clement Ley's theory that the sunsets are due to ice spiculæ. (*Nature*, XXIX, p. 175.)

Mr. Bishop, of Honolulu, made the observations of the sunset colors on September 5, 1883, and immediately suggested that they were due to clouds of dust from Krakatoa which had come around westward three-fourths the circumference of the earth. (*Nature*, XXIX, p. 174.)

A number of interesting items were published at the May meeting of the Mauritius Meteorological Society. (*Nature*, vol. XXX, p. 279.)

An excellent map of the Krakatoa region is given in *Nature*, XXIX, p. 228.

The Royal Society has appointed a special committee, of which Mr. G. J. Symons, of London, is the chairman, to collect data.

The report of the French mission sent to Krakatoa in June, 1884, is briefly summarized at *Nature*, vol. XXX, p. 372; the report of Mons. R. D. M. Verbeek is translated in full in vol. XXX, p. 10.

392. Mr. S. E. Bishop, of Honolulu, from observations at Strong's Island, latitude 5° N. and longitude 162° E., fixes September 7 at that place, or September 6 of London reckoning, as the date when the coppery sunset became visible, which, with some other data, gives him the conclusion that this stream of smoke was progressing westward at the rate of 64 miles per hour. J. Joly, of Dublin, from observations by Captain Thomson, of the Medea, computes 17 and 21 miles as the height of the column of dust seen to shoot up from Krakatoa on August 26. (*Nature*, XXX, pp. 23 and 72.)

393. Rev. Samuel Haughton gives a computation of the depression of the sun and the height of the dust, and argues the incredibility of certain phenomena, especially Mr. Bishop's results. (*Nature*, XXIX, p. 470.)

394. A. Ringwood read before the Canterbury Philosophical Institute of New Zealand a paper on red sunsets, giving an interesting summary of previous records. (*Nature*, XXX, p. 301.)

395. A previous eruption of Krakatoa had occurred in May, 1883; but from a letter from Robert Leslie it appears that the remarkable sunsets were observed still earlier by Mr. Neison at the Natal Observatory, where they increased in intensity from February to June, 1883. (*Nature*, XXX, p. 463.) But the descriptions of the phenomena are not such as to assure us that the twilight phenomena at Natal were at all equivalent to those seen later in the year in northern latitudes.

396. Tissandier communicates to the Paris Academy a comparison between the atmospheric conditions of 1831 and 1883. The eruptions at Sicily in the former year were analogous to those of Krakatoa, and were followed by corresponding optical phenomena. (*Nature*, XXIX, p 376.)

397. M. Gay, on June 23, read a paper to the Paris Academy on persistent rain and its possible connection with recent volcanic eruptions.

He gives a comparison with the eruptions of May, 1783, in Iceland; July, 1831, in Sicily; Cotopaxi, in 1856; Vesuvius, 1862, and Krakatoa, 1883. In all of these cases similar twilight colors have been followed by heavy rains. (*Nature*, XXX, p. 229.)

398. Mr. J. Murray communicates to the Royal Society, Edinburgh, an extensive paper on volcanic ashes and cosmic dust, showing, among other things, that in proportion as ashes are collected at a greater distance from a volcano, so are they less rich in minerals, while the proportion of vitreous matter more and more predominates. (*Nature*, XXIX, p. 585.)

399. [In 1884 the twilight phenomena of 1883 were renewed, beginning in England about September 10, and Berlin, September 13, Vancouver's Island, September 30, while the records in England for 1883 were about September 20. The maximum brightness in 1883 was about the 20th of December, in 1884 it was later, but in general was decidedly inferior and shorter than in 1883-'84.]

400. M. Cornu maintains before the Paris Academy of Sciences that the white or reddish tinted cloud-like nebulous halo or corona that has permanently accompanied the sun during the whole of 1884, and of which he gives many observations, probably has some connection with the Krakatoa eruption. That in fact a cloud of particles, with a nearly uniform average diameter, was projected by the volcano, and is held in suspension in the higher region of our atmosphere. (*Nature*, XXX, p. 556.)

401. This cloud has been observed in Dublin since November, 1883. (*Nature*, XXX, p. 663.) [It has also been observed in Washington since about that date, with a peculiar streaky appearance, visible before sunset, the lines being inclined to the west horizon, at an angle of about 30° slanting down toward the south. The pink or purple tint has been especially visible during the whole of any fair day. When the sun is behind a cloud, and the observer examines the tints by sky between the clouds, the purple is traceable for 30 to 40 degrees from the sun.]

402. According to A. Grützmacher, in *Das Wetter* for April, 1884, and Köppen, in the D. M. Z., this brownish red ring about the sun appears to have first been observed in Europe at the end of November 1883, and not to have existed earlier. It is essentially different from ordinary solar halos, and the material from which it comes must exist beyond the highest cirrus clouds. Its explanation as a diffraction phenomenon is undoubtedly correctly given by Kiessling. (*D. M. Z.*, I, p. 256.)

403. O. Jesse, of Steglitz, near Berlin, has endeavored to compute the altitude of the layer of dust or mist that has hypothetically caused the twilight phenomena of 1883-'84. After fully explaining his theoretical formula he applies it to observations made by himself on eight days at Steglitz, from which he concludes an altitude of 17 kilometers. The

individual determinations range from 12 to 18. These observations properly refer to the upper limit of what von Bezold calls the first purple light, and which Jesse has observed as being the limit of the earth's shadow. In an appendix Jesse adds to the preceding observations, which were taken between November 1883, and March 1884, a few taken in the latter part of March with better apparatus, and which give results varying between 7 and 12 kilometers, as though a decided diminution had taken place in the altitude of the dust, which was greatest in January, and least at the end of March. (*D. M. Z.*, I, p. 127.)

404. All the phenomena in connection with the green sun, as recorded in India, have been collected by Prof. C. M. Smith, of Edinburgh, from which he concludes that the green sun must be distinguished from the remarkable sunsets of 1883–'84. His own view is that there is some definite evidence to show that the phenomenon is due to aqueous vapor, for it is not so uncommon as is generally supposed. (*Nature*, XXX, p. 347.)

405. The Krakatoa eruption has also given rise to an interesting series of studies into a so-called wave of pressure that seems to be traceable from that region outward throughout the whole globe. General Strachey (*Nature*, XXIX, p. 181) seems to have first called attention to the fact that a series of remarkable barometric fluctuations recorded by self-registers in various parts of Europe harmonized with the hypothesis that a wave of atmospheric compression, starting from Krakatoa and moving outward in all directions, after concentrating at the antipodes returned to Krakatoa, making a complete circuit of the earth in from thirty-four to thirty-seven hours; after crossing at Krakatoa, this again made the circuit of the earth in a second period of thirty-six hours. Four such circumnavigations are claimed by some of those who have studied the subject; where self-recording registers are not available, attempts have been made to utilize the automatic registers of pressure kept in connection with the city gas-works.

406. Rykatcheff, of St. Petersburg, from a study of all known data on the velocity of the Krakatoa atmospheric wave, fixes it at 327.9 meters per second, corresponding to the velocity of sound at the temperature of —10 C., which temperature is attained at an altitude of 4,000 meters in the atmosphere when the temperature at the earth's surface is +12 C., so that we may conclude that these great waves of pressure move with the velocity of sound. The amplitude of this wave for European stations was 1.3 millimeters, but it was almost twice as great, namely 2.5, at the island of South Georgia. (*Z. O. G. M.*, XIX, p. 431, and *Nature*, XXX, p. 135.)

407. General J. T. Walker, of the India Geological Survey, gives the results of observations of the earthquake ocean wave. (*Nature*, XXIX, p. 376.)

XII.—MISCELLANEOUS RELATIONS. (*a*) PERIODICITY AND SUN-SPOTS; (*b*) HYPSOMETRY; (*c*) BIOLOGY; BOTANY; (*d*) GLACIERS, AND CLIMATES OF GEOLOGICAL EPOCHS.

408. A. Belikoff and M. Rykatscheff, from a study of the anemograph records at St. Petersburg, conclude that although one year's record is scarcely sufficient to demonstrate the ebb and flow of the atmospheric tide, yet there are indications of a north and south movement during the lunar day having one maximum and one minimum, and an east and west movement having two maxima and minima, and therefore similar to the ocean tide. (*D. M. Z.*, I, p. 373.)

409. E. Leyst has investigated the possible influence of the moon upon the velocity of the wind as shown by the study of the St. Petersburg records for 1878. He finds a slightly greater velocity for the lower culmination of the moon as compared with the upper culmination, and again a slightly greater velocity for the six hours after the upper culmination or the lower as compared with the six hours before; he finds the influence of the moon on the velocity more regular and sometimes greater than that of the sun. [Nothing is said as to the probable error of the mean values as used by him, and his results are certainly very anomalous.] (*Z. O. G. M.*, XIX, p. 142.)

410. Mr. B. Stewart and W. L. Carpenter communicate to the Royal Society a report on diurnal temperature ranges at Toronto and Kew, compared with apparent inequalities of short period in sun-spot areas. They find that periods of 24 and 26 days in the sun-spot and temperature coincide; the solar maximum occurs eight or nine days after the Toronto maximum, and the Kew maximum seven days after the Toronto and one or two before the solar. [If the phenomena occur in the order Toronto-Kew-solar, then the causal connection seems very indefinite.] (*Nature*, XXX, p. 119.)

411. Charles Chambers, of Bombay, has investigated the relation between sun-spots and variations of the daily range of atmospheric temperature; he finds the maxima of variation in daily amplitude agreeing with the minima of sun-spots. By the same method he finds also variations parallel with the phases of the moon.

He has also compared the daily variations of magnetic declination with the sun-spots and the moon's phases, and finds an agreement between them. He also finds a very large periodicity in declination coincident with the revolution of the planet Mercury about the Sun. In most cases the amplitude of the above parallel variations seems too small to be real, but in the case of Mercury the amplitude is quite large. (*Z. O. G. M.*, XIX, p. 226.)

412. J. Liznar states that while the variation of the declination of the magnetic needle with sun-spots has been recognized for some time, yet so far as he knows, the other magnetic elements have not been compared; he therefore compares the horizontal intensity, the vertical in-

tensity, total intensity, and dip at St. Petersburg with the sun-spots and shows that all have a parallelism. (*Z. O. G. M.*, XIX, p. 415.)

413. Prof. W. Förster has investigated the periodical changes in the azimuth and level of the fundamental bed of masonry established in the Berlin Observatory for the support of the meridian instruments. He concludes from the study of 42 years of observations as follows:

1. Neither the permanent nor the periodical changes show any dependence on the water or moisture in the earth.

2. Those movements that are certainly separated from small movements in the instrument itself and are plainly to be considered as movements of the whole pier, go through a distinct annual and an 11-year period, and both have a thermal character.

3. The thermal effect corresponds to a rise of temperature or solar radiation at the time of the sun-spot maxima.

4. These observations have a general interest, and not purely local. Professor Förster shows that they depend not on local temperatures of the air, but on the intensity of solar radiation of which the disturbance of the pier is a sort of summation. He has therefore lately sunk three thermometers into his pier in order to understand better its internal temperature.

414. [If we couple Förster's investigation with that of Dr. B. A. Gould into similar motions throughout the world, we should conclude that these changes take place not in the pier but in the ground on which the observatory stands; but this seems impossible in the case of Berlin, where the observatory is surrounded by trees and buildings. The fact that greater solar heat is radiated at times of sun-spot maximum was clearly shown by the present writer's study of temperatures observed on the Hohenpeissenberg. (*Amer. Jour. Sci.*, 1869.)]

415. A similar investigation on the movements of the pillars of the observatory at Neuchatel, 1859 to 1881, has been made by Hirsch and Faye, showing the same periodical and irregular variations as at Berlin. (*Nature*, XXVIII, p. 216.)

416. Prof. Paul Reis has made an exhaustive study of the high and low waters of the Rhine in connection with the question of a possible sun-spot periodicity. With regard to the floods he finds maxima agreeing with the principal maxima of sun-spots as given by Wolf's relative numbers, and concludes that there is very nearly a period of 110 years, which is twice Fritz's 55-year period, and ten times Wolf's sun-spot period, and which, therefore, would be 111 years. This conclusion, based upon observations since 1705, is confirmed by the records of high waters running back as far as the year 14 B. C. He, of course, maintains that the cause of the overflows is cosmic or extra-terrestrial. Dividing his high waters into four classes, he finds that the prediction of a high water of the first class can be made with greater certainty than a weather prediction. (*Z. O. G. M.*, XVIII, p. 261.)

417. Lieut. v. d. Groeben, of the Engineer Corps in Berlin, endeavors

to elucidate the connection between the sun-spots and rainfall by a study of the hydraulics and physics of the Mississippi River, as given in the work of Humphreys and Abbot, together with more recent data, and offers the following conclusions: From the observed discharge of the Mississippi since 1819 there follows neither a confirmation nor a refutal of Meldrum's law, according to which there should be heavier rainfall at the time of the sun-spot maxima and slight rainfall at the time of the minima. On the other hand, from the magnitude and irregularity of the variations in the discharge compared with the periodical influence which in favorable cases should have been expected according to Meldrum's law, we may safely conclude that in the Mississippi watershed influences of this regular form are completely obscured by the incomparably greater effect of apparently irregular variations of wind and weather. If, however, this is our result for the Mississippi in spite of the magnitude of the area represented by it and in spite of the relative simplicity in the form of the North American continent, then it follows that a compensation of the disturbing influences by the accumulation of a larger number of observations from all parts of the earth is in general not probable and that it is therefore to be recommended that the further investigation of the subject be based not upon an empirical accumulation of observations but rather upon a more careful, intelligent selection. In this selection the principal circumstances to be attended to are as follows: A constant direction of the wind through a whole year or at least during the greater part of the year; when possible, such a position of the area of observation that this wind shall be from the ocean; the greatest imaginable simplicity of topographic contour. If from the observations that have so far been discussed we separate those that correspond to this point of view, then from them almost without exception can be deduced a confirmation of Meldrum's law.

If we go still further and inquire into the possible reason of the parallelism between sun-spot frequency and precipitation, or, what is almost the same, between sun-spot activity and radiation of solar heat, it would then appear as if a comparison of sun-spot phenomena with the periodical geyser eruptions would give not only a credible answer to this question, but also would be proper to give information on many other problematic phenomena observed on the sun-spots. According to the results of these comparisons the sun spots are nothing else than the external evidences of the peculiar process of cooling on the sun, which goes on in such a way that hot masses periodically come from the interior to the surface, and in this way the loss of heat caused by radiation must from time to time be always renewed; and in this way these comparisons acquire still another special interest, for they appear to present a solution of the problem of the conservation of solar energy that leaves nothing to be desired in the way of simplicity, of course with the important reservation that this conservation of energy can only be a temporary state of transition. (*Z. O. G. M.*, XIX, p. 1.)

418. Prof. William Ferrel has investigated the effect of uprising currents upon the atmospheric pressure both in his original memoir of 1857 and in his later enlargement of the same published as Meteorological Researches by the United States Coast and Geodetic Survey. In the third part of these Researches he gives a hypsometric formula in which the terms depending on the movements of the atmosphere are introduced, but, as he himself shows, these can only be appreciable in most extreme cases. In other respects, however, his formula also represents our latest knowledge on the subject of the attraction of the earth and the effect of atmospheric moisture. (*Z. O. G. M.*, XIX, p. 466.)

419. [The formula given by Upton in his method of reducing the barometer to sea-level (Ann. Rep. Chief Signal Officer, 1882) introduces some new values of numerical coefficients which, if combined with the improvements made by Ferrel, give us a formula more painfully exact than that of Rühlmann, but the practical value of these in ordinary hypsometry is, of course, limited by the accuracy with which we can ascertain the true average temperature of the air.]

420. Paul Schreiber has published the second edition of his Hand-Book of Barometric Hypsometry. This work has been for some years by far the best general guide to those who wish to derive the best results attainable by the use of the mercurial or aneroid barometer. The author neglects certain refinements relative to the effect of aqueous vapor, but for general use his work is highly to be recommended. Of course, those having a large number of stations at their disposal may prefer to work out special methods, as has been done by Mr. G. K. Gilbert for the use of the United States Geological Survey, but it is not yet certain that they will obtain results of much greater accuracy.

421. R. Hult has discussed the mass of phænological observations accumulated for the last 10 years in Sweden. One hundred and fifty-seven stations have afforded about 150,000 observations. The previous labors of the French botanist, Adamson, had shown that the development of the buds is determined by the sum of the daily mean temperatures since the beginning of the year. Boussingault had, however, shown that the temperature during the period of rest from growth need not be taken into consideration, and that the length of the growing period is therefore inversely proportional to its mean temperature. Linsser concluded that the sums of the temperatures above zero which are necessary to effect development of a plant at any two localities are in direct ratio to the sums of all temperatures at both stations above zero. J. Sachs, the ablest botanical physiologist of the present time, has studied the subject from an entirely different side. He has by direct experiment with different plants determined the influence of temperature on the development and growth, and found that for each arrangement of external conditions about any plant there is a minimum, a best, and a maximum temperature. That is to say, a certain amount of heat is necessary, namely, the temperature minimum; an increase of

temperature accelerates the development up to a certain limit, which is the best temperature; every increase above this retards the development up to a certain limit, which is the maximum possible, beyond which the growth of the plant must cease.

The results attained by Hult do not entirely agree with any of the preceding. He finds that the precipitation in Sweden is nowhere so slight that vegetation is regularly restricted, nowhere so great that the blossoming or leafing is disturbed, but the ripening of the fruit occurs at the season of greatest rainfall, and this stage of plant growth is affected by the rain. The blossoming of any plant throughout the whole of Sweden occurs at the same temperature, but when we pass to Lapland and Jempland, the very rapid progress of the spring temperature cannot be followed by the plant, and the blossoming occurs subsequent to the occurrence of the normal temperature. (*Z. O. G.M.*, XIX, p. 139.)

422. A. Spamer communicates the following conclusions as to the dependence of the growth of wood upon meteorological factors:

1. Temperature and precipitation are the meteorological phenomena that affect the process of the formation of wood.

2. Of these two variable quantities during the principal period of growth, the rainfall diminishes the formation of wood while the heat increases it.

3. The principal period of wood growth is from July to October, at least for the plants which are very sensitive to frost.

4. The rainfall seems to influence growth more than the temperature. [Excess of rain diminishes growth more than excess of temperature increases it.]

5. The growth of different plants is not affected in the same degree by the rain; some are affected more by rain and others by the temperature.

6. In many periods only one of these factors appear to exert any influence, the other being inactive.

7. Possibly this anomaly may be explained by observations of the duration of insolation.

8. The increase of carbonaceous compounds goes parallel with the increase in the inorganic constituents of the wood.

9. The aqueous component of the wood diminishes when the carbonaceous increases.

10. The so-called ripe wood [the heartwood] differs from that which is less ripe by a greater amount of ashes and carbon. (*Z. O. G. M.*, XIX, p. 93.)

423. M. Bergmans, of Flushing, has studied the difference between sea and continental climates as shown by the vegetation, especially by a study of the plants ordinarily cultivated in the temperate zone. He finds that the difference in vegetation is due not to the difference in mean temperature but to the difference in the amount of sunshine; clear

skies and full sunshine means high midday temperature and low temperatures or frosts at night time; high temperatures in the summer and low temperatures in the winter. These extreme variations in temperature decide whether any given plant can thrive or not. The actual development of the plant depends upon the action of sunlight. (*Nature*, xxx, p. 392.)

424. W. O. Atwater offers experiments to show that certain plants grown under natural conditions do directly assimilate the atmospheric nitrogen.

425. [Although the amount of this assimilation is not at present sufficient to be of any importance to meteorology, yet the establishment of this fact, which has been controverted by so many eminent chemists, would be of importance in studying the climates of past geological epochs, when other plants and other gases were present.] (*Nature*, xxx, p. 553.)

426. C. Ferrari has published in the Agricultural Annals for 1883 a comparison for Italy between the statistics of harvests and the meteorological phenomena. He deduces a number of practical rules, such as the more rain we have in summer the greater the harvest of corn; but for wheat, rye, and other grains great rain frequency is injurious, and the harvest is greater as the temperature is higher and the cloudiness less

427. Prof. H. Hoffmann, communicating the result of the most recent observations on the thermal constant of vegetation, compares the figures for a number of plants for Upsala and Giessen, and concludes that the results agree quite as closely as can be expected, showing that there is no change in the constant depending on latitude or climate. (*D. M. Z.*, I, p. 407.)

428. General Strachey has endeavored to establish a simple method of computing the quantity of heat received at any place and proper to use as a standard for comparison with the progress of vegetation. Recognizing the fact that it is not the absolute temperature that should be summed up from day to day for this purpose, but that it is the excess above a definite minimum and that below this minimum active vegetative processes are not possible, General Strachey has endeavored to establish the minimum limit and to devise convenient methods for summing up the excess above it. Numerical tables are given to assist the computation. By assuming 42° F. a base temperature, it results that a very close approximation is given by simply subtracting this figure from the true mean temperature on each pentade and summing the remainders. (*Z. O. G. M.*, XIX, p. 425.)

429. [In studies looking to the prediction of hatching of "locust" eggs (see Reports of the United States Entomological Commission) the present writer used 50° F. as a minimum limit for the development of the eggs.]

430. Dr. A. Frankel gives an account of experiments on the influence

of rarefied atmosphere upon the animal system. He concludes that the rarefaction influences the metastasis by depriving the blood and the tissues of some of their necessary oxygen, and that this want of oxygen entails an excessive destruction of albumen, the constituents of which are in part deposited as fat. (*Nature*, XXVII, p. 191.)

431. S. A. Hill, of India, has investigated the connection between statistics of death and crime and the variations of the weather in that country. He finds that a mere rise of temperature has comparatively little effect and the effect of varying humidity is still less, while the variations of diurnal range in temperature are quite appreciable. The most prevalent fatal diseases are the malarial fevers, and these are doubtless increased by the rainfall, so that dry years are healthy and wet ones unhealthy. Crimes of violence in India may be said to be proportional in frequency to the tendency to prickly heat; that excruciating condition of the skin induced by a high temperature combined with moisture. (*Nature*, XXIX, p. 338.)

432. N. Alcock discusses the effect of climate on the color of the human skin, and maintains that the effect of great sunshine upon the pigment is to intensify the skin color and cause the intense blackness of the races that live in the tropical regions where the chemical power is intense for a vertical sun. (*Nature*, XXX, p. 401.)

433. The glaciers of the Straits of Magellan are described by W. J. L. Wharton (*Nature*, XXX, p. 177), who has made measures upon their dimensions and movements.

434. Prof. F. Simony, in a study of the glacial formation of the Karls-Icefield, the largest glacier in the Austrian Alps, finds that during the last thirty years a steady diminution has taken place in the average quantity of ice, and at the present rate only twelve or fifteen years more will be required to bring it back to the minimum condition which local report said it had attained some three hundred years ago. It would seem, then, proper to assume that long prevailing secular changes in climate take place that are best shown by such phenomena as the glacier changes of corresponding long periods. (*Z. O. G. M.*, XIX, p. 127.)

435. W. R. Browne presented to the Royal Society in 1882 a very suggestive paper on the causes of glacial motion, which however seems not to have been printed until a year after, and which should be read in connection with the following. (*Nature*, XXVIII, p. 235.)

436. A. Irving, in a paper on the mechanics of glaciers, states that there is as yet no explanation of the fact that the movement is greater by day than by night and greater in the summer than in the winter. This he attributes to the fact that the solar rays entering into the interior of the glacier are there transformed into heat and melt the ice, whose variations have thus a daily and annual period. (*Nature*, XXVII, p. 553.)

437. Dr. R. von Lendenfeld has made a survey and study of the gla-

ciers of New Zealand, showing that the present glaciers are as large and extend to as low levels as those in Norway, while the mean temperature of New Zealand is 11° C., as compared with 3° in Norway. The cause of this glaciation is considered to be the greater humidity of air and more copious rain and snow of New Zealand, due to the greater expanse of water in the southern hemisphere. The author considers that the glacial period in New Zealand, during which the sounds in the southwest coast were scooped and not filled up with *débris* but since which time the present small rapidly increasing alluvial deposits have all accumulated, must therefore have been very recent. [A greater expanse of water in the northern hemisphere with a north polar continent would similarly give us higher temperatures and heavier glaciers. (*Nature*, XXX, p. 651.)

438. E. Hill, of Cambridge, England, has given a mathematical investigation of the effect of fluctuations of solar heat and terrestrial radiation upon terrestrial temperatures, and especially upon the glacial epoch. He shows that the temperatures of the continents are now lower under the present periodical change from day to night and from summer to winter than they would be if precisely the same quantity of heat were communicated to them continuously and uniformly. The same is also shown for the ocean; periodical changes in the transmitted heat increase the evaporation but diminish the radiation. An increase in the amplitudes of these heat variations will exaggerate the increase or diminution of the mean values of evaporation, &c. An increase in the eccentricity of the earth's orbit exaggerates these amplitudes, and therefore lowers the mean annual temperature in the one hemisphere and increases it in the other, also increasing the evaporation in the one hemisphere and diminishing it in the other. Increased evaporation may increase the snowfall. This is, therefore, possibly appreciable in connection with the glacial epoch as discussed by Hill in the Geological Magazine, November, 1881. (*Z. O. G. M.*, XIX, p. 260.)

439. W. F. Stanley maintains the improbability of the theory that former glacial periods in the northern hemisphere were due to eccentricity of the earth's orbit and to its winter perihelion. He quotes Ferrel and Hann to show that the mean temperature of the southern hemisphere is now equal to if not higher than the northern, although the northern is the most glaciated, so that, whatever may be the relative position of the earth's orbit and axis, it could have no more influence than now prevails. He explains glaciation as a local phenomenon, dependent upon the distribution of land and water and attending changes in aerial and oceanic currents. (*Nature*, XXX, p. 526.)

440. A. Blytt, by the study of the distribution of the plants of Scandinavia at the present time and at the time of the formation of the peat-bogs, concludes that since the glacial epoch the climate has experienced periodical changes, in that dry continental periods have interchanged with moist insular climates. These periodical climatic changes he traces

back to periodic variations in the temperature of the sea. He concludes that when the winter agrees with the earth's aphelion the currents will probably increase, and when the winter agrees with the perihelion the currents will slightly diminish; therefore at present northwestern Europe is enjoying relatively gentle rains and a large difference between the winter and summer temperatures, which conditions will be reversed in about 10,000 years with the change in position of the earth's axis. In other regions than Europe the effect of this change may be different. Thus the eastern part of North America will, with winter in the aphelion, have stronger northwest winds, and therefore a more severe climate; the same for Eastern Asia, while the western coast of North America will be affected like Europe. But such changes must also affect other portions of the ocean and of the world, causing periodic changes in the climate over the whole earth's surface. (*Z. O. G. M.*, XIX, p. 413.)

441. Dr. Penck, of Munich, in some remarks on the glacial epoch, says a numerical expression for the difference between the climate of the glacial epoch and that immediately before and after it is found by a comparison of the limit of perpetual snow for that and the present epoch. This limit was at that time decidedly lower than the present, namely, at 45° N. latitude 1,300 meters lower, and at 26° N. latitude, 1,000 lower. In the southern hemisphere the probable depression of the snow limit at 30° S. was 1,000 meters, and at 45° S. at least 800 meters lower than now. During the glacial epoch the region of perpetual snow in the northern hemisphere was lower than it is to-day in the southern, and in the southern it was much lower than now. An interchange of the climatic relations of the north and south hemispheres would not of itself produce a glacial epoch. The remarkable agreement between the intensity of the present glaciation and that of the glacial epoch justifies the assumption that the latter occurred under general external relations such as now prevail; in fact, it can be proven that the glacial epoch occurred during the present arrangement of land and water, and not with a lower but rather a higher elevation of the land. The mass of sea water that was at that time on the land in the shape of ice was approximately 56,000,000 cubic kilometers. A characteristic of the glacial epoch, the recurrence of the glaciation as recognized in northern Europe and America, and which repetitions, as the Alps show, were separated by epochs of mild climate whose durations were greater than the time that has now elapsed since the last glaciation. The great extent of the glaciation is explained by no other theories as to its cause except Croll's theory of the alternate glaciation of both hemispheres, and the theory of the existence of a sensible cold period over the whole earth; but the periodicity of glaciation is explained only by Croll's theory, so that this is the most probable, although great difficulties stand in its way. (*D. M. Z.*, I, p. 473.)

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SUBJECT AND AUTHOR INDEX.

PHYSICS.

By George F. Barker, M. D.,
Professor of Physics in the University of Pennsylvania, Philadelphia.

GENERAL.

The address of Lord Rayleigh, president of the British Association, at the Montreal meeting, reviewed very ably the recent progress of physical science. One of the most striking advances is in the production and application of electricity upon a large scale, the reaction of which upon the advancement of pure science has been most salutary. The electro-magnetic rotation of the polarized ray, which Faraday used the most refined means to detect, can now be produced through 180°; the question of magnetic saturation, in the hands of Joule a purely scientific one, is now a fundamental one in every dynamo machine. The laws of alternating currents show some curious modifications by induction in powerful machines. Suppose an electro-magnet wound with two parallel wires, through one of which an alternating current passes and develops a certain amount of heat in the circuit. If now the second wire receive the current, it would at first be supposed that the heat effect would be doubled. In fact, however, the total current, since it is governed by the self-induction of the circuit, would not be increased at all; and hence the heating effect would be actually halved in the doubled conductor. On the question of electric standards, Lord Rayleigh mentions his own measurements of the Clark cell as 1.435 theoretical volts, and of the electro-chemical equivalent of silver, 4.025 grams per ampere-hour, as closely according with that of Kohlrausch. Another direction of marked progress is in thermo-dynamics. Some confusion has arisen in consequence of applying the first law too rigidly, unmodified by the second. The latter teaches that the real value of heat as a source of mechanical power depends upon the temperature of the body in which it resides. Every change, chemical, thermal, or mechanical, which takes place or can take place in nature does so at the cost of a certain amount of available energy. If, therefore, we wish to inquire whether or not a proposed transformation can take place, the question to be considered is whether its occurrence would involve dissipation of energy. If not, the transformation is absolutely excluded

The fraction of the total energy which can be converted into work, according to the second law, depends on the difference of the initial and final temperatures. In optics, Cornu's ingenious application of Doppler's principle to determine whether a spectrum line is solar or terrestrial in origin is mentioned. An image of the sun is thrown on the slit of the spectroscope and caused to vibrate two or three times a second, so that the light entering the instrument comes alternately from the advancing and the retreating edge. Since the line, if solar, suffers in this way alternate displacements, it appears to tremble, while if terrestrial it appears fixed. In acoustics the curious fact is stated that while when a pure note, such as that of a tuning-fork, is sounded, we cannot tell whether the sound comes to us from in front or from behind, when any other sort of sound is produced, from a clap of the hand to the clearest vowel sound, the discrimination is not only possible but easy and instinctive. The address concludes with a discussion of the importance of experimental science in a system of education. (*Nature*, August, 1884, xxx, 410–417.)

As president of the mathematical and physical section, Sir William Thomson gave an address entitled "Steps toward a kinetic theory of matter," in which, after giving a *résumé* of the kinetic theory of gases, and discussing especially the theory of the repulsive action between molecules in collision, he takes up the question of elasticity and shows that any ideal system of material particles acting on one another mutually through massless connecting springs, may be perfectly imitated in a model consisting of rigid links jointed together, and having rapidly rotating fly-wheels pivoted on some or on all of the links. He figures two systems, each consisting of two hooked rods, connected in the first to an elliptical spring, and in the second to the opposite corners of a square frame loosely articulated, upon each of the sides of which, as an axis, is a fly-wheel or gyrostat in rapid rotation. If either of these systems be hung up by the hook on one of its projecting rods, and a weight be placed on the hook on the other rod, the weight when first put on will oscillate up and down, and will go on doing so forever if the system be absolutely unfrictional. Thus, out of matter possessing rigidity, but absolutely devoid of elasticity, a perfect model of a spring has been made in the form of a spring-balance. (*Nature*, August, 1884, xxx, 417–421.)

The second and third volumes of the "Travaux et Mémoires" of the Bureau International des Poids et Mesures have been published during 1883 and 1884, the first volume having appeared in 1881. The second volume contains papers by Dr. Benoit on his expansion experiments, by M. Marek on the methods and results of the weighings made at the bureau from 1879 to 1881, and by Dr. Broch, the director, on the expansion of mercury. The third volume contains an account of the modes of comparison of the standards, with descriptions of the apparatus used and a complete statement of the observations and the methods of their

reduction; a careful account by M. Marek of the excellent normal barometer and cathetometer in use at the bureau, and a description of the methods of calibrating the thermometers used during the weighings; and illustrations of the specific gravity apparatus, and of the method of Stas for clearing the surfaces of metals by a jet of alcohol vapor. Besides these memoirs, the International Committee publishes reports to the Governments represented, of which the seventh appeared in 1884. Great Britain has now a representative on this committee. (*Nature*, April, XXIX, 529; October, 1884, XXX, 612. *Science*, III, 305, March, 1884.)

Herschel has given a short method of converting yards into meters, and the converse, based upon the ratio of the meter to the yard obtained by W. A. Rogers, in his comparisons of the "mètre des archives" with the standard yard. This ratio, which is 39.37027:36, agrees with the simpler one, 35:32, very closely, the error being only 1 part in 8,000. Herschel's rule is as follows: To convert yards into meters, subtract one-tenth and add one-seventh of that tenth. If great accuracy be required, add one one-hundred-and-thirtieth of that seventh. The result is accurate to the sixth decimal place. To convert meters into yards, add one-tenth, subtract one-sixteenth of that tenth, two one-hundredths of that sixteenth, and one-twentieth of that two one-hundredths. The error is less than 5 inches in the kilometer, or less than 2 decimeters in the mile. (*Nature*, July, 1884, XXX, 312.)

Johnstone Stoney has called attention to the fact that Clarke's determination of the yard in metrical units differs from Kater's by more than the difference between Clarke's and the simple value 914.4 millimeters for the yard. Hence the yard may be assumed to have this value, with an error of less than a fifth metret (10^{-5}) in the meter. So the pound may be assumed as 453.6 grams, with an error of one-fourth of a grain avoirdupois, on the authority of Professor Miller; and the gallon may be considered as 4,544 cubic centimeters, with an error of less than one cubic centimeter in 10 liters. (*Nature*, January, 1884, XXIX, 278.)

Rowland has proposed to construct scales with his ruling-engine, which will enable the physicist at any time, by purely optical means, and without knowing the coefficient of expansion of the metal or its temperature, to obtain the value of the length of the scale in terms of the wave-length of any given ray of light. These scales are simply to be straight pieces of speculum metal, ruled with lines just like an ordinary grating, except that the length of the lines is to be only about one centimeter, every one-hundredth line being somewhat longer than its neighbors; the whole ruled slip is to be one decimeter in length. From the manner of ruling it will be easy to count the whole number of lines in the length of the strip, and then, by a simple use of the scale as a grating in a suitable spectrometer, the whole length may be immediately found at any time, in terms of any specified wave-length of light. (*Science*, September, 1884, IV, 296; *Nature*, October, 1884, XXX, 596.)

F. J. Smith has described a new transmitting dynamometer or ergometer, as he calls it, which resembles the early dynamometer of Morin in having two pulleys, the angular advance of one being regulated by a spring. In the Morin instrument, however, an extended piece of steel formed the spring; and in the modified form of it proposed by Ayrton and Perry spiral springs were used. In the latter form the springs are liable to fly out by centrifugal force, and, moreover, a special optical arrangement is required for reading the angular advance. In Smith's ergometer there is no tendency in the spring to fly, and the tension is read directly upon a dial. (*Nature*, July, 1884, xxx, 220.)

Brackett has devised a dynamometer especially adapted for measuring the energy expended on a dynamo-machine. The machine to be tested is so supported that it can turn freely through a small arc of a circle, the center of which is in the armature axis. When the armature is rotated, the circuit being closed, a mechanical couple is set up between this armature and the field magnets, which tends to make the latter revolve in the same direction as the armature. The value of this couple is ascertained by measuring the value of the equal and opposite couple required to maintain equilibrium. This is done by means of a lever-arm fixed to the machine or cradle, provided with a sliding weight sufficient to maintain the machine at zero. The length of the lever-arm and weight being known, it is necessary to know only the number of revolutions in order to calculate the energy. If W denote the weight, L the lever-arm, and n the number of revolutions in a minute, the energy expended will be represented by $2\pi LWn$. (*Am. J. Sci.*, January, 1884, III, xxvii, 20.)

Boltzmann, by means of Carnot's principle and the theory of probabilities, has calculated the energy developed in chemical combination, considering only the cases where the substances are gaseous both before and after the reaction, and where the diatomic molecules dissociate into atoms of the same kind. Assuming that the heat of dissociation is independent of the temperature, the formula gives as the number of calories (gram-degrees) required for the dissociation of one gram of nitrogen tetroxide, 151.3; and of iodine vapor, 112.5. (*Ber. Ak. Wien*, 1884, 184; *J. Phys.*, II, III, 274, June, 1884.)

Sir William Thomson described at Montreal a gyrostatic balance for measuring the vertical component of the earth's rotation, which consisted of a gyrostat supported on knife-edges attached to its containing-case, with their line perpendicular to the axis of the interior fly-wheel, and above the center of gravity of the fly-wheel and frame-work, by an exceedingly small height when the frame-work is held with the axis of the fly-wheel and the line of the knife-edges both horizontal, and the knife-edges downward in proper position for performing their function. The apparatus, when supported on its knife-edges, with the fly-wheel not spinning, may be dealt with as the beam of an ordinary balance. Let now the frame-work bear two small knife-edges or knife-edged holes, like those of the beam of an ordinary balance, giving bearing-points

for weights in a line cutting the line of the knife-edges as nearly as possible, and of course approximately perpendicular to this line, and, for convenience of putting on and off weights, hang, as in an ordinary balance, two very light pans, by hooks, on these edges, in the usual way. Now, with the fly-wheel not running, adjust, by weights in the pans, if necessary, so that the frame-work rests in equilibrium in a certain marked position, with the axis of rotation inclined slightly to the horizontal, in order that the axis of the fly-wheel, whether spinning or at rest, may always slip down so as to press on one and not on the other of the two end plates belonging to its two ends. Now unhook the pans and take away the gyrostat and spin it, replace it on its knife-edges, hang on the two pans, and find the weight required to balance it in the marked position, with the fly-wheel now rotating rapidly. This weight gives an accurate measure of the vertical component of the earth's rotation. (*Nature*, September, 1884, XXX, 524.)

Respighi has made a series of experiments at the Roman Observatory in order to determine the intensity of gravity. For this purpose he used a pendulum composed of a sphere of lead 0.11698 meter and weighing 9.43515 kilograms, suspended to a steel wire varying in length in the different experiments from 5 to 7.8 meters. The total weight of the wire and the other accessories was only $\frac{1}{100}$ of the weight of the lead sphere. A correction of 3.4^{mm} was, however, necessary, in consequence of the rigidity of the wire, between the length of the actual pendulum and that of the equivalent simple pendulum. The oscillations were determined by the method of coincidences, a mercury surface being raised at the proper time until a point attached to the pendulum made contact with it at each oscillation, and made an electro-chronographic record. The results gave for the value of the seconds pendulum 0.9934891 meter, and for the value of g 9.805343 meters. These figures differ by only the $\frac{1}{7000}$ part of their value from those calculated by Biot—0.9933380 and 9.803851. (*Atti Acc. Lincei*, III, XII, 346; *J. Phys.*, February, 1884, II, III, 95.)

An article by Hall upon inertia has called out replies from Hastings, Mendenhall, and others. Hastings says that the difficulty in the correct use of the word arises from the fact that it has been used in two perfectly legitimate senses—one qualitative, the other quantitative. In the qualitative sense it simply implies the truth of Newton's first law of motion; in the quantitative sense it is mass and nothing else. On account of this ambiguity all careful writers and teachers have long since practically abandoned it. (*Science*, III, 482, 559, April, May, 1884.)

MECHANICS.

1. *Of Solids.*

Dobbie and Hutcheson have described an apparatus for the rapid determination of the specific gravity of solids, founded on the measurement of the volume of water displaced. It consists of a U-tube, one

limb of which is about 5^{mm} in diameter and somewhat longer than the other, which is much larger, and closed at the top by means of a movable piece of tube of the same size, carrying a stop-cock and attached by a rubber band. The small tube is graduated into cubic centimeters above a point on the same level as one of several lines drawn on the larger tube. To make an observation the tube is filled up with water to one of these lines and the substance whose specific gravity is required is dropped in the larger limb. Of course if it sinks it displaces its own volume of water, and by blowing through the stop-cock the level of the water is depressed below the original mark. It is then allowed to rise again slowly until the surface reaches the line at which it stood before the solid was introduced. By reading the bulk of the water displaced in the smaller tube, which may be done with much accuracy, and by dividing the weight of the body previously ascertained by this number, the specific gravity is obtained. (*Phil. Mag.*, V, XVII, 459, June, 1884.)

Belli has observed that if two glass plates be made to adhere by applying them exactly to one another, and are then left so that gravity acts upon them, they always separate, no matter how small may be the weight of the one united to the other by adhesion. Obviously molecular attraction cannot be the cause of this phenomenon. The long duration of the adhesion arises simply from the slowness with which air penetrates between the plates. Stefan has come to the same conclusion from a mathematical investigation. (*Il Nuovo Cimento*, XIII, 34; *J. Phys.*, December, 1884, II, III, 552.)

Turpin and Warrington have repeated Bottomley's experiment of cutting through a block of ice by means of a wire having weights attached to its ends, with a view of noting the effect of varying conditions. Bottomley had observed that string would not cut through the ice, and explained the fact by supposing that the string is not a sufficiently good conductor to relieve itself of the cold in front and pass it back to the water behind. To test the effect of conductivity, wires of silver, copper, brass, iron, and German silver, 0.67^{mm} diameter, were employed, each carrying 2.5 pounds. The results show that the time increases as the conductivity decreases. In a second experiment the wire was of iron, and was loaded in the first case with 5 pounds, in the second with $7\frac{1}{2}$, and in the third with $12\frac{1}{2}$ pounds. It was found that the time taken was approximately inversely proportional to the load. Pfaff's experiment of placing a tube upright on a block of ice, pressing it down by a weighted lever, while maintaining it at 0° by surrounding it with snow, was then repeated, using tubes of copper, brass, lead, and glass, each about a foot long and of three-eighths inch bore, the weight being 2 pounds. In four hours the copper tube had penetrated 100^{mm}, the brass tube 35^{mm}, the lead tube 7^{mm} and the glass tube 3^{mm}; showing conclusively that when the temperature is not lower than 0° C. the chief factor is the lowering of the freezing point by pressure, and not the plasticity of ice. If the result takes place below 0°, as Pfaff states, the

explanation is not easy without admitting a certain amount of plasticity in ice. (*Phil. Mag.*, August, 1884, V, XVIII, 120.)

Krouchkoll has noticed that perfectly clean platinum readily amalgamates with mercury, but that aluminum and iron do not. On attempting to unite mercury with a scraped surface of aluminum, this metal oxidizes with great facility. If, however, the aluminum be made the negative electrode in acidulated water, this metal becomes strongly charged with hydrogen; and now if it be dipped into mercury at the bottom of the vessel, it unites with it instantly. On exposure to the air it is tarnished at once. A wire of iron acts in the same way. The author suggests that the action of sodium in facilitating amalgamation is due to its reducing action. (*J. Phys.*, March, 1884, II, III, 139.)

2. *Of Liquids.*

E. Wiedemann has calculated, from certain experiments made by Berthelot, that the force necessary to separate two adjacent layers of water cannot be less than 55 atmospheres. (*J. Phys.*, December, 1884, II, III, 555.)

Reinold and Rücker have continued their studies on liquid films, and have observed that the disturbing action of the electric current, previously noticed, is due to the transference of liquid by this current in its own direction, thus thinning the film, or the reverse, according to the direction. By forming a plane film between two horizontal wires, illuminating it by the calcium light and projecting its image on a screen, the authors showed the motions of the bands of color in the direction of the current. (*Nature*, December, 1884, XXXI, 186.)

Schiff has determined with care the capillary constant of a large number of liquids at their boiling points. For this purpose he used two capillary glass tubes, one 1.3^{mm} in the bore, the other half as much, connected so as to form the legs of a U tube. This tube, after being filled with the experimental liquid, is hung in a wider vessel, at the bottom of which a little of the liquid is kept boiling. From the difference in level of the liquid in these two connected capillary tubes, as measured at a temperature which must be very nearly the boiling point, the surface tension at that temperature is readily deduced. To this surface tension, in milligrams per millimeter, divided by the relative molecular weight (and multiplied for convenience by 1,000), Schiff assigns the symbol N. He illustrates its significance by pointing out that in the case of a capillary elevation against a vertical wall wetted by the liquid, it represents the number of molecules raised above the free surface per unit length of the wall. The results obtained show that not only is this number N the same for isomeric substances, but that it is often the same for liquids of very different chemical constitution, and that it is possible to replace a certain number of atoms of one kind by a certain number of another kind, without producing in the value of N an alteration which comes within the limit of precise observation. In these

replacements C = 2H, O = 3H, and Cl = 7H; so that from the formula of a body the value of N can be deduced, and thus the surface tension at the boiling point calculated. (*Liebig's Annalen*, March, 1884, CCXXIII, 47; *Nature*, October, 1884, XXX, 618.)

Krouchkoll has observed that isolating liquids, such as carbon disulphide, ether, and turpentine, not miscible with water, acquire a conductivity when in contact with this liquid. He then made an investigation to ascertain whether the capillary constant at the surface of contact between one of these liquids and water varied under the action of an electro-motive force. The results of his experiments prove that this variation actually takes place, and that it is in the same direction as in the case of the surface of separation between water and mercury. (*J. Phys.*, II, III, 303, July, 1884.)

Wroblewski's experiments on the direct liquefaction of oxygen by compression gave for the density of the liquid only a superior limit, given as 0.94. By observing that the tension of oxygen at $-130°$ is near that of carbon dioxide and nitrogen monoxide at 0°, knowing that the density of liquid CO_2 is 0.9471 and of N_2O is 0.9370, the author has calculated the density of liquid oxygen to be 0.899. This agrees well with Cailletet and Hautefeuille's results, who obtained, by compressing a mixture of 7 volumes of CO_2 and 1 of O, the value 0.89 at $-23°$ C. and 300 atmospheres pressure; and from a mixture of N_2O and O, the value 0.94 at $-23°$ and 300 atmospheres. The value 0.899 also agrees with the pressures observed by Pictet in his experiments on the compression of oxygen. (*Wied. Ann.*, XX, 80; *J. Phys.*, II, III, 93, February, 1885.)

Bender has investigated the law of density of saline solutions by comparing together solutions containing, for a given volume, a given number of equivalents of various salts. Using, for example, chlorides, he finds that the difference between the density of the solution of any salt whatever and that of a solution of sal-ammoniac is proportional to the number of equivalents contained in the solution, provided always that this number does not exceed four. The law extends to other radicals besides chlorine, so that the density of any saline solution whatever may be represented by the formula—

$$d_\mu = (d_\mu)_{NH_4Cl} + \mu\,(m_b + m_s)$$

in which μ is the number of equivalents of the salt contained in the solution and m_b and m_s the moduli of the metal and of the acid radical. These moduli have been experimentally determined by the author, and from these the density of any normal solution whatever may be calculated. (*Wied. Ann.*, XX, 560; *J. Phys.*, May, 1884, II, III, 221.)

Mendelejeff has communicated to the Russian Chemical Society a paper on salt solutions. It would be easy to prove, he says, with the data of Gerlach, Marignac, Cremers, and Schiff, that the volume of a given amount of a salt in its solutions (of a molecule, for instance) varies with the variations of temperature and the degree of concentration of the solutions. It increases with both of these values; and it might

be concluded therefrom that the force on which solution depends varies with the degree of concentration. Still, another conclusion may be arrived at if Grassy's measurements of the decrease of volumes of NaCl and of $CaCl_2$ be taken into account. Interpolation shows that these solutions are reduced in volume by pressure as the amount of the dissolved salt varies; and the reduction of volume which accompanies the solution enables us to calculate the corresponding pressure. It appears that to each molecule of NaCl dissolved in 100 parts of water corresponds a nearly permanent pressure of about 120 atmospheres, whatever be the degree of concentration. For $CaCl_2$ the pressure also remains constant, but is nearly three times as great. Thus, if the tendency towards solution be measured by pressure, it results, for the two salts above mentioned, that the first amounts of salt dissolved exert the same pressure as the last, which bring the solution near to saturation. (*Nature*, March, 1884, XXIX, 512.)

Nicol has published a series of papers on salt solutions. In the first he considers the phenomenon of equilibrium in these solutions, and concludes that when salt solutions are mixed the tendency is to form the system which will occupy the smallest volume, since then the equilibrium is stable. In the second he discusses the saturation of salt solutions, and finds that, as a general rule, the solubility of two salts together is greater than when separate. In the third he continues the discussion on the molecular volumes of salt solutions, and treats especially of water of crystallization. He points out that water of crystallization has no effect on the molecular volume of a salt in solution; and hence draws the inference that in all probability water of crystallization does not exist in solution. In the fourth paper he gives the results of his investigations on the nature of solution, particularly on the boiling points of salts solutions; and he shows that by rise of temperature the attraction of salt for salt is so greatly diminished that it is equivalent to an increase in attraction of salt for water. (*Phil. Mag.*, February, June, September, October, 1884, XVII, 150, 537; XVIII, 179, 364.)

Guthrie also has continued his researches upon solution, and has published the results of a study of the ammonia group (including the ethylamines and aniline) in its behavior with water, and also the results obtained by shifting the temperatures up on the scale until the solid fuses, so as to establish the continuity of the phenomena of fusion with those of solution. He establishes the fact that certain bodies originally solid may at high temperatures become miscible with water in all proportions—a fact of great geologic interest, since it throws light on the pyrohydration of igneous formations, as cryohydration has done for floes. (*Phil. Mag.*, V, XVIII, 22, 105, July, August, 1884.)

3. *Of Gases.*

Andreæ proposes the following lecture experiment to illustrate Boyle's law: In a glass tube about a meter long and from $1\frac{1}{2}^{mm}$ to 2^{mm}

internal diameter, closed at one end and open below, is introduced a thread of mercury about 250^{mm} in length. This incloses a certain volume of air, about 40 cubic centimeters. The tube is supported on a stand, which has a scale on white paper divided into centimeters, and can be placed on the table with either end vertical. When the closed end is uppermost, the pressure on the inclosed air is the difference between the barometric height and 250; and when inverted, it is the sum of the barometric height and 250. If the barometer stand at 750^{mm}, the pressure in the former case is 500^{mm} and in the latter $1,000^{mm}$. Consequently the volume is reduced from 40 cubic centimeters to 20. (*Phil. Mag.*, July, 1884, XVIII, 80.)

Diakonoff has devised a new form of siphon barometer, which, being easily filled, is more readily portable than the ordinary forms. The barometer tube proper, which at its upper third has a diameter of 0.012 meter, is continued above by a capillary tube of the same length, which turns downward. At bottom it opens into the side of a larger tube, the upper end of which is closed with a cork, while the lower end is drawn out to enter one end of a rubber tube, the other end of which is fastened to the lower end of a funnel tube the length of the barometer and a little more. After the apparatus has been thoroughly cleaned, it is filled by pouring mercury in the funnel tube, whence it rises through the barometer tube and overflows at top, the excess of mercury falling through the small tube into a reservoir below, into which its end dips. When all the tubes are full, the rubber tube is detached from the funnel tube, and a portion of the mercury is allowed to flow out till the column stands at the proper height. It is read by means of a graduated scale and two verniers. (*J. Phys.*, II, III, 27, January, 1884.)

Grumnach has suggested the use of a vacuum tube in connection with the barometer, so that by electrical means the rarefaction may be ascertained. He states that the opinion entertained until recently that the electric discharge would not take place through the best attainable vacuum is not absolutely true, since recent experiments have shown that the passage of the electric discharge depends largely upon the form of the electrodes. In a vacuum in which the spark will not pass if the electrodes are simple wires, it readily passes when they are of the form of balls or cylinders. The author's barometer is connected with a mercury pump and with a Geissler tube, operated by a small induction coil. As the exhaustion proceeds, the nitrogen bands first disappear, then the lines *F* and *G* of hydrogen and some lines of mercury. Finally the phosphorescence of the glass appears first at the negative end, then at the positive end, and finally throughout the tube. At last the discharge is totally arrested or is slowly intermittent. Comparisons with this normal barometer show differences too large to be attributed to errors of observation. The author finds that a difference of 0.07° C. produces an error of 0.01^{mm} in the barometer reading. (*Wied. Ann.*, XXI, 698; *J. Phys.*, II, III, 264, June, 1884.)

Frank Waldo has suggested the use of Wright's apparatus for distilling mercury in the direct filling of barometer tubes. By attaching the tube to be filled to the end of the distilling-tube, the mercury, as it condenses, passes into it at once, and without coming in contact with the air. Certain precautions are detailed in the paper. (*Am. J. Sci.*, January, 1884, III, XXVII, 18.)

Schumann has made a long series of experiments on the coefficient of friction of gases and vapors and its dependence on temperature. He concludes (1) that values of this coefficient calculated by the formula of Maxwell show greater deviations from each other than would correspond to errors of observation, and this particularly at high temperatures; (2) that by introducing a correction this formula gives numbers which at ordinary temperatures show close agreement with those obtained by the method of transpiration; (3) that, owing to absorption, the method of transpiration gives for gases too high values and for vapors too low values of the coefficient of friction; (4) that the dependence of the coefficient on the temperature increases with the temperature; (5) that the coefficients of all the vapors examined have almost the same function of temperature; and (6) that the relation found by Puluj to exist between length of path and refractive index holds for the vapors of homologous ethers at corresponding temperatures. (*Wied. Ann.*, XXIII, 353, November, 1884; *Phil. Mag.*, December, 1884, V, XVIII, 544.)

Winkelman has studied the phenomena of diffusion of gases and vapors, in order to compare the results obtained with those calculated from the formulas of Stefan and Meyer. His experiments were made in a tube drawn out at the lower end into a portion of uniform but of much finer bore than the upper portion, and graduated. This lower portion contained the liquid which was to be vaporized, the gas into which it was to diffuse being passed into the upper portion by means of an entrance and exit tube. For diffusion of steam into hydrogen, into carbon dioxide, and into air, discrepancies between the actual results and the theoretical ones deduced by Meyer's formula were observed. For alcohol and for ether vapor diffusing into these three gases, a fair agreement with Stefan's formula was observed. The mean length of free path of the vapor molecule can be obtained from the latter formula, at least approximately. (*Wied. Ann.*, June, 1884, XXII, 1; *Am. J. Sci.*, July, 1884, III, XXVIII, 70.)

Guglielmo also has determined the coefficient of diffusion of the vapor of water into air, carbon dioxide, and hydrogen. He gives for the first, 12.86 at 8° and 13.05 at 15°; for the second, 46.95 at 18°; and for the third, 8.38 at 18°. The last two values are 3.52 and 0.628 times the coefficient of diffusion into air. By Meyer's formula the author has calculated the mean length of free path of the molecule of vapor of water in an atmosphere of this vapor. He finds the value 0.00000891, that directly obtained by Kundt and Warburg being 0.00000649. The fun-

damental units used are the centimeter, gram, minute. (*Il Nuovo Cimento*, XIII, 104; *J. Phys.*, December, 1884, II, III, 555.)

Bunsen has investigated the condensation of carbon dioxide gas on the surface of glass. The glass employed was the fine-spun variety used in weaving. The space occupied by 150 grams was only 100 c. c. The length of filament was 62 geographical miles and its surface 23 square meters. The specific gravity of the glass was 2.50596. The apparatus consisted of a graduated glass tube, closed above by a stop-cock; above this is a length of the same tube, in which the spun glass is placed, and which is closed above by a second stop-cock. The whole is placed over a mercury cistern, and the lower part filled with dry CO_2. The upper part is then exhausted, and the experiment commences by opening the communicating stop-cock. At the end of a given time the pressure of the gas is determined anew, and from this the weight of the gas which has been condensed is readily calculated. Bunsen's experiments began on the 20th of April, 1880, and at the end of three years the condensation did not seem to have terminated. During the first year it was 49.21 c. c., during the first two years 57.94 c. c., and during the three 69.98 c. c., or for the three years 5.135 c. c. per square meter. Granted that capillary attraction can be perceived, as Quincke states, at a distance of 0.000005^{cm} from the surface, the 5.135 c. c. condensed on a surface of 10,000 sq. cm. would occupy a space of 0.05 c. c. and have been condensed by a pressure of 102.7 atmospheres. Since carbon dioxide is liquid at 57.5 atmospheres at the temperature of the experiments, there can be no doubt that the surface of the glass was covered with a layer of liquid carbon dioxide. (*Wied. Ann.*, XX, 545; *Phil. Mag.*, March, 1884, V, XVII, 161; *J. Phys.*, June, 1884, II, III, 262.)

Blondlot has considered the influence of electrification on the maximum tension of a vapor in contact with its liquid, and concludes that the maximum tension of the vapor in contact with this electrified surface is smaller than it would be if the surface was not electrified, by an amount represented by $2\pi\mu^2\frac{\delta}{\Delta}$, in which μ represents the electric surface density and $\frac{\delta}{\Delta}$ the ratio of the densities of the vapor and the liquid. (*J. Phys.*, October, 1884, II, III, 442.)

ACOUSTICS.

Martini has studied the phenomena of the production of sound by the flow of liquids. His apparatus consisted of a vertical tube either of glass or metal, within which was a metallic disk perforated at its center with a hole, the diameter of which was equal to the thickness of the plate. The production of the sound is determined by the periodicity of the flow, the tone produced being either the fundamental note of the liquid column or one of its harmonics, according to the position of the regulating cock. The sounds produced seem like those of a closed pipe.

They are the same whatever the position of the disk in the tube. Two vibrating cylinders give notes whose pitch is inversely as their linear dimensions. If the disk is on the side where the water enters, the number of vibrations given by the same cylinder is proportional to the square root of the charge. The nature of the tube is without influence on the pitch of the note. (*J. Phys.*, May, 1884, II, III, 218.)

Neyreneuf, following Tyndall, has called attention to the facility with which sound traverses the interstices of solid bodies when the air in them is continuous. If the conjugate-mirror experiment be repeated with a thick sheet of cotton wool between the mirrors, the sound does not seem to be sensibly altered in intensity. Two such sheets may be interposed without preventing a sensitive flame from showing agitation when placed in the conjugate focus. A sheet of filter paper is equivalent to two sheets of cotton. To prove how difficult it is to destroy resonance, the author states that he has performed the reflection experiment with one of the mirrors covered with cotton upon its reflecting surface. (*J. Phys.*, May, 1884, II, III, 209.)

Neyreneuf has also continued his researches on the transmission of sound by gases, and now gives the results obtained with nitrogen monoxide and dioxide, ammonia, and ethylene. With nitrogen monoxide and air the ratio of the flame distances was as 1.32 : 1 as a mean, a value identical with that obtained for carbon dioxide. For ammonia and air the ratio of the flame distances was 1.46 in place of 1.42. No differences were observed between air, nitrogen dioxide, and ethylene. He has observed that the damping effect of solid particles is very marked. By using a long inverted U-tube of rubber filled with hydrogen the author has shown that the sound is much less enfeebled than when traversing the same thickness of air. (*C. R.*, XCVIII, 980, 1264, April, May, 1884.)

Elsas has studied the laws of the forced vibrations of plates; *i. e.*, those which the plate is made to execute under the influence of a vibrating body in communication with it. The plate, circular in form, and made of cardboard, gelatin, ebonite, &c., is fixed by its center to a sewing needle perpendicular to its plane. A flexible cord, stretched by a weight, is attached to the needle by one end, and by the other to the prong of a tuning-fork. By means of sand and lycopodium on the plate the position of the nodes and venters could be determined. The results show (1) that such a plate gives the nodal figures of Chladni, the center being a node; (2) that these figures never have an uneven number of diametral nodal lines; (3) that, while always even, these lines degenerate frequently into hyperbolic curves, the vertices of which are on the same straight line; (4) that for the same reasons the nodal lines are wanting in the central portions, but appear on the periphery of the plate; and (5) that the nodal lines of communicated vibrations never cut each other. These results are in accord with those previously obtained with membranes. (*Wied. Ann.*, XIX, 474; *J. Phys.*, January, 1884, II, III, 33.)

Mercadier has presented to the French Academy the results of his researches on the laws of transverse vibration of elastic rods. The rods were made of iron and steel, were rectangular in section, and were vibrated electro-magnetically, the vibrations being recorded on the chronograph. He finds (1) that the vibrations are independent of the width, (2) are directly proportional to the thickness (measured in the direction of vibration), and (3) are inversely as the square of the length. Representing these results by the formula $n=k\frac{e}{l^2}$, Mercadier has calculated the value of the coefficient k for steel from his measurements, and finds it to be 5,329,503, while Poisson's formula gives 5,310,866. The mean value, 5,320,134, being adopted, the author has calculated the number of vibrations for different rods and compared them with those given by experiment. The results are in very satisfactory accord, and show that by means of this coefficient the dimensions of a rod required to give any special pitch may be readily calculated. (*C. R.*, XCVIII, 803, 911, March, April, 1884; *J. Phys.*, May, 1884, II, III, 189.)

R. Weber has devised an electric siren, which is simple in principle and which has many advantages. Its principal element is a disk, whose periphery is divided into alternate segments of conducting and non-conducting substance. Fifteen of these disks are placed upon an axis, each being 4^{cm} in diameter and separated by 3^{mm} from the others. The first wheel has twenty-four metallic contacts, the second twenty-seven, the third thirty, and so on up the gamut. Upon the edges of these disks fifteen springs press, for the purpose of making electric contact with the metallic segments, and so completing the circuit through the axis. Each spring has its own cell of battery, the current passing through a telephone, in which is heard a note corresponding to the number of interruptions made by the disk in the same circuit. The siren may be driven by any form of power, but a small electric motor the author finds very serviceable. A counter permits the number of rotations to be determined. One curious result was obtained when four disks were used, having the same number of teeth but differently spaced, the metallic part being in the first $\frac{1}{12}$, in the second $\frac{3}{12}$, in the third $\frac{6}{12}$, and in the fourth $\frac{8}{12}$ of the insulating part. The sound produced by the first, though feeble, was accompanied by its double octave; by the second, the tones 1:2:3:4:5:6:8; the third gave 1:2:3; and the fourth, 1:2:4. Resultant tones were also very satisfactorily studied. (*J. Phys.*, December, 1884, II, III, 535.)

Blaikley has continued his studies upon the phenomena connected with the determination of the velocity of sound in air by means of the nodal points in smooth brass tubes. He concludes (1) that these tubes must speak with a pure tone; (2) that if partials are present the tubes must be of such form as to have their proper tones in exact agreement with the harmonic series; (3) that the air-blast must not constrain the pipe to speak any other than its natural resonant pitch; (4) that in

smooth tubes the diminution of velocity is proportional to r^{-1} and to $n^{-\frac{1}{2}}$, as determined by Helmholtz; (5) that the velocity in free air for sound waves of low intensity, or just audible, is 331.676 meters at 0° C.; and (6) that the ratio between the two specific heats of air, as deduced from the Newtonian velocity, 279.955 meters, and the above value, 331.676 meters, is 1.4036. (*Phil. Mag.*, October, 1884, V, XVIII, 328.)

Rayleigh has examined the conditions of sensitiveness of smoke-jets and jets of colored liquid, paying especial attention in the former to the illumination, and exalting the effect by means of resonators. The maximum sensitiveness was reached at 256 vibrations. By using the stroboscopic method, the serpentine motion of the jet previous to rupture was clearly seen. For liquid jets, water colored with permanganate was used in water containing ferrous sulphate. The notes for maximum sensitiveness were far lower than for smoke-jets, forks vibrating from 20 to 50 times a second producing the maximum effect. This is due, not to the difference of density, but to a difference of viscosity. (*Phil. Mag.*, March, 1884, V, XVII, 188.)

Fuchs has suggested a simple method of analyzing the vowel sounds, which is easy to put in practice. One of the ears is closed with a piece of wet tissue paper, and to the other is applied one end of a rubber tube tipped with horn, the other end being placed in the mouth. The mouth is then given the configuration corresponding to the vowel *A*, for example, and the various keys of a piano in good tune are struck, beginning with the highest notes of the scale. The mouth cavity acts like a resonator, so that when a note is struck which accords with it this note is re-enforced by resonance and appears stronger than the others. In this way the harmonics which are characteristic of the vowel for which the mouth is set may be easily determined. The sonometer may be used in this experiment in place of the piano. (*Wied. Ann.*, XXI, 513; *J. Phys.* II, III, 548; *Phil. Mag.*, May, 1884, V, XVII, 410.)

Melde has investigated the effect of placing the vibrating fork at a position on a string other than its extremity. If it is at the middle point, the vibrations are symmetrical and the two halves take identical forms. Since the point of attachment cannot be a node, the cord does not vibrate if the sound of the fork is that of an even harmonic of the cord. In short, each half vibrates as if it was an entirely distinct string, vibrated at their common extremity. If the fork is not at the middle point, the form of the string during the vibration is dissymmetrical with relation to the middle. The forks were vibrated electrically. (*Wied. Ann.*, XXI, 452; *J. Phys.*, December, 1884, II, III, 547.)

Thompson has given an illustrated description of the sound-mills constructed by Dvorāk. Two of these act by the repulsion of resonant-boxes. In the first four, resonators are mounted so as to revolve horizontally; in the second the resonator is a cylindrical box, which revolves on its axis. The third is called a "sound radiometer" and the fourth

an "acoustic anemometer." They are all ingeniously constructed. (*Nature*, February, 1884, XXIX, 363.)

St. George has patented a novel form of phonograph. A round photographic plate is revolved on its axis by means of any suitable motor. The light falls on the plate perpendicularly through a small opening, which, by means of a screw connected to the axis by bevel gear, is carried slowly toward the center. If the light were uniform, a spiral line would be traced on the plate. But over the opening is a slide connected by a lever with a diaphragm and mouth-piece, so that on talking into the latter the vibration of the diaphragm varies the size of the opening; so that there is produced on the plate a spiral band of varying width corresponding to the vibrations of the plate. If now the prepared plate be rotated under such conditions that a beam of light sent through this photographic image falls upon a selenium photophone transmitter, the tones of the voice are reproduced. (*Science*, IV, 124, August, 1884.)

Dr. Zintgraff, who has gone into the interior of Africa with Chavanne, has taken with him a phonograph, for the purpose of fixing the speech and melodies of hitherto unknown tribes, which when received by the instrument will be forwarded to scientific men in Germany. The apparatus, now used for this purpose for the first time, was made by Fuhrmann, of Berlin, in *fac simile* of one kept in that city, so that the plates made in Africa can be put upon the Berlin machine and caused to reproduce the sounds received. (*Nature*, March, 1884, XXIX, 460.)

Cross has given a lecture on the determination, history, and present standards of musical pitch. Under the first head he considered the methods by the sonometer and the tuning-fork and the tonometer of Scheibler. The fork he considered the only good standard, since it changed its rate by less than $\frac{1}{9000}$ per degree centigrade. He gives the following table, prepared in 1880, giving the results of some of his measurements:

	Number of vibrations, C₃.
Ritchie, copy of Chickering standard	269
Mason & Hamlin, French pitch	259.1
Hook & Hastings, old flat organ pitch	264.6
Organ in Church of the Immaculate Conception, Boston	266.7
Chickering's standard fork	268.5
Smith American Organ Company	267.2
New England Organ Company	268.2
H. F. Miller pianos	268.9
Hook & Hastings standard	270
Weber pianos	270.3
Thomas pitch, 1879	271.1
Boston Music Hall organ	271.2
Steinway's pitch	272.2
Highest New York pitch	273.9

In 1882–'83 the standard used by the Boston symphony orchestra was an A fork of 448 double vibrations; in 1883–'84 it was a French A of 435 vibrations. The standard French pitch of the New England

Conservatory of Music is a middle C, a *true* sixth below the normal A; hence 261 vibrations. Hence the C fork used with an orchestra which has A for its standard does not agree with this. Chickering's and Miller's forks are C standards, a *tempered* sixth below the French A; hence 258.7 vibrations. Thomas's present pitch is an A, a little sharper than the French A. In Handel's time the C fork had 249.6 vibrations; hence the difficulty now experienced in singing old music. (*Science*, May, 1884, III, 667.)

Compton has devised a method for autographically recording the vibrations of a tuning-fork in terms of the beats between it and a siren. Three pens make records on a strip of chemical paper. The first marks seconds, the second the revolutions of the siren, and the third the beats. Since the first pen is connected to the back contact of a relay, and the second to the front contact, both pens cannot record together; and when the coincidence is perfect, the siren mark is omitted. The beat record is made by placing a membrane over the small end of a resonator, with an adjustible platinum contact in the main circuit of a relay, the pen being in the secondary circuit. The adjustment is so made that when a fork placed in front of the resonator beats with the siren, the circuit is broken, the armature falls back and closes the secondary circuit, producing a dash on the paper. The record, therefore, shows three sets of marks: First, the beat dashes; second, the siren revolutions; and third the seconds marks. From the two latter the pitch of the siren is determined; and this, with the two former, determines the pitch of the fork. (*Am. J. Sci.*, June, 1884, III, XXVII, 444.)

HEAT.

1. *Production of Heat.—Thermometry.*

Lippmann has objected to the thermometric scales in use as being entirely arbitrary. Neither temperature nor intervals of temperature are measurable magnitudes, in the proper sense of the word. To measure a quantity is to find its ratio to a magnitude of the same kind taken as a unit. The only physical magnitudes capable of measurement are those of which multiples can be constructed. But this is not true of temperature, since intervals of temperature cannot be added. He suggests, therefore, an absolute thermometric scale founded on the quantity of mechanical work done by heat-engines. According to Carnot's principle, the maximum efficiency is the same for all heat-engines working between the same limits of temperature. If such an engine take a quantity of heat, Q, from the source of heat and give up the quantity Q′ to the refrigerator, then the ratio $\frac{Q'}{Q}$ has a minimum value for a given interval of temperature, independent of the nature of the engine. The temperature-interval is represented by that fraction of a heat-unit which is transferred to the refrigerator without having been transformed

into work. The interval between two temperatures is represented not by a difference but by a ratio, the ratio between the quantities of heat received and rejected by a perfect engine working between these temperatures. (*J. Phys.*, February, II, III, 53; July 1884, II, III, 274.)

Pettersson has laid down the following principles with reference to the measurement of heat: First, measurements of heat should be executed at constant temperature, *i. e.*, without the aid of thermometers; second, the amount of heat developed in calorimetric experiments should be directly transformed into work and measured in absolute units; third, the principle should be applicable to the measurement of all kinds of caloric energy, such as specific heat, radiant heat, the heat absorbed or evolved in chemical reactions, &c. Several forms of apparatus are described which the author has used for such measurements, including the form finally adopted. (*Nature*, July, 1884, XXX, 320.)

Guthrie has studied the thermal and corresponding volume-changes attending the mixture of liquids, the substances used being alcohol, carbon disulphide, amylene, ether, chloroform, and benzene. (*Phil. Mag.*, December, 1884, V, XVIII, 495.)

Cailletet has constructed an apparatus for the continuous production of intense cold, which consists of a closed steel cylinder containing a coil of copper pipe projecting from each end. Two copper tubes are screwed into the cylinder; one of these communicates with the author's mercurial piston-pump, the other receives the ethylene, which has been compressed by the pump and cooled by methyl chloride. In this way a circuit is formed, in which the same quantity of ethylene is repeatedly evaporated in the copper coil, producing intense cold, and then compressed again by the pump, it being cooled sufficiently by the evaporation of methyl chloride. (*Science*, April, 1884, III, 526.)

Barbier has demonstrated Regnault's principle between weight and stem thermometers, that if they are in accord at two fixed points they remain in accord at all temperatures, as follows: If the temperature t° be defined by saying that $5{,}550^{mm}$ of mercury at 0° become $5{,}550+t^{mm}$ at t°, then in the stem thermometer it will occupy at 0° $5{,}550^{mm}$ of volume $= n$; and at t°, $n+t$ volumes. In the weight thermometer, containing all the mercury at 0°, t volumes will flow out at t°, leaving n volumes; *i. e.*, the fraction $\frac{t}{n+t}$ will flow out, and $\frac{n}{n+t}$ will remain. The ratio of these values is $\frac{t}{n}$, which is proportional to t as in the stem thermometer. Since $t = \frac{1p}{c\,\mathrm{P}-p}$, the two thermometers are directly comparable with one another when c is made equal to $\frac{1}{5550}$. (*C. R.*, November, 1884, XCIX, 752.)

Mayençon has devised an instrument, which he calls a thermogalvanoscope, for the purpose of rendering the expansion of wires visible at a distance, serving, therefore, as an indicator of temperature. It con-

sists of a metallic wire fixed at the ends, and connected at its middle point with a cord passing over a pulley above and having a counterweight below. When the wire elongates by heat, its center falls, rotates the pulley, and causes an index to traverse a graduated scale. The apparatus is very sensitive as a thermoscope, and by passing a current through the wire it may be used as a galvanoscope. (*J. Phys.*, September, 1884, II, III, 393.)

Clodig has proposed to furnish steam-boilers with mercury thermometers, the reservoir (which is of iron) being placed in the steam, while the stem (which is of iron within and glass without the boiler) passes through the metal. The pressure of the steam compresses the reservoir of the thermometer and increases the rise of the mercury in the tube, thus acting as a manometer. (*J. Phys.*, May, 1884, II, III, 222.)

Browne has given a *résumé* of the most important pyrometers at present in use. In Siemens's instrument the temperature is determined from the increase in the resistance of a platinum wire as the heat increases. Tremeschini uses the expansion of a thin plate of platinum which is heated by a mass of metal previously raised to the temperature of the medium, in order to determine the temperature. Trampler's pyrometer is based on the differential expansion of iron and graphite. The Gauntlett instrument is similar, except that fire-clay is used instead of graphite. Ducomet's pyrometer consists of a series of rings having progressively lower melting points. These are strung on a rod, which is pushed into the medium to be measured, the rings being pressed together by a spring. When any ring softens it is pressed out, the column shortens, and a simple apparatus shows the temperature. The instrument known as the thalpotasimeter is based on the principle that the tension of a saturated vapor is proportional to the temperature. A tube of metal is partly filled with a liquid suited to the temperature to be measured, and connected with a pressure-gauge. Ether is used from 100° to 220° F., water up to 680°, and mercury above this. Saintignon's pyrometer, as improved by Boulier, depends on the water-current principle, the temperature being determined by noting the amount of heat communicated to a known current of water circulating in the place whose temperature is desired. At Limoges and at Sèvres this pyrometer has been satisfactorily used for determining the temperature of the porcelain furnaces. (*Nature*, August, 1884, XXX, 366.)

Von Baumhauer has contrived a modified form of thermo-regulator for use with paraffin baths to render the temperature constant. It consists of an air-reservoir containing mercury, plunged into the paraffin. As the temperature rises, the expansion of the air forces the mercury up a central tube until it cuts off the flow of gas entering by a smaller tube adjustable within the latter. (*C. R.*, August, 1884, XCIX, 370.)

Ericsson has published a description of the sun-motor which he had in operation in the summer of 1883, as the result of twenty years' experiments. Its leading feature is that of concentrating the radiant heat

by means of a rectangular trough having a curved bottom, lined on the inside with polished plates, so arranged that they reflect the sun's rays towards a cylindrical boiler placed longitudinally above the trough. The trough is 11 feet long and 16 broad, and receivês a beam of sunlight of 23,400 square inches in section. The boiler is $6\frac{1}{4}$ inches in diameter and 11 feet long. The motor employed is a steam-engine with a cylinder 6 inches in diameter and 8 inches stroke. In the trials the previous summer the average speed of the engine was 120 turns a minute, the pressure on the piston being 35 pounds per square inch. From these results, Ericsson deduces some conclusions with reference the solar temperature. The area of a sphere whose radius is equal to the earth's mean distance from the sun being to the area of the latter as $214.5^2 : 1$, while the reflector of the solar motor intercepts a sunbeam of 23,400 square inches section, it follows that the reflector will receive the heat developed by $\frac{23,400}{214.5^2} = 0.508$ square inch of the solar surface. Hence, as the boiler of the motor contains 1,274 square inches, the solar rays acting on it are diffused in the ratio 1,274 : 0.508, or 2,507 : 1. Since the radiant heat transmitted to the reflector by the sun is capable of imparting a temperature to the boiler of 520° F. above that of the atmosphere, accepting Newton's law that "the temperature is as the density of the rays," the temperature imparted to the boiler of the sun-motor proves that the temperature of the solar surface cannot be less than $520° \times 2,507$, or 1,303,640° F. (*Nature*, January, 1884, XXIX, 216.)

Ayrton and Perry have presented a paper on the indicator diagram of the gas-engine to the London Physical Society, intended to teach engineers a new mode of studying these diagrams. The paper gives the most recent results obtained with Dowson gas, a large wooden model of the Otto engine enabling the operations during the cycle to be understood. By means of tables of the composition of the Dowson gas and coal gas, of the air required for their combustion, and of their specific heats, as well as those of their products, the characteristic equation of the fluid used in the engine may be determined. Three practical methods of determining the rate of gain of heat by the fluid during the forward stroke are given, this rate being compared everywhere with the rate of doing work, by means of a diagram. If W represent the indicated work in one cycle, 5.64 W is the total energy of combustion of one charge; and this is expended as follows: 1.45 W is the work done in the forward stroke, 2.22 W is given to the cylinder by radiation in the forward stroke, 1.5 W is carried off through the exhaust-pipe, 0.47 W is given to the cylinder as heat after the exhaust-valve opens. (*Phil. Mag.*, July, 1884, V, XVIII, 59; *Nature*, May, 1884, XXX, 47.)

Thurston has published the results of tests made on an Otto gas-engine by Brooks and Steward at the Stevens Institute of Technology. The air and gas were both measured by meter, and the fact was proven that

combustion continues even after expansion has progressed considerably. The heat consumed was distributed as follows: Indicated work, 17 per cent.; exhaust, 15½ per cent.; water-jacket, 52 per cent.; loss by radiation, &c., 15½ per cent. The engine was rated at ten-horse power, and the cost of operating it is given as 8¾ cents per horse-power per hour. (*Van Nostrand's Mag.*, February, 1884, XXX, 89; *Science*, April, 1884, III, 496.)

2. *Expansion and Change of State.*

Thorpe and Rücker have applied the theory of Van der Waals to the establishing of an important relation between the absolute temperature of boiling of a liquid, the volume at this temperature, and a constant, which they have determined to be 2, or very near this number. Mendelejeff had already established the formula $\frac{1}{V}=1-kt$ for the expansion of liquids, in which k is a modulus varying with the liquid. This author now shows that if the dilatation of gases be expressed by $V_t=1+at$, and that of liquids by $V_t=\frac{1}{1-kt}$, then $2t_1=\frac{1}{k}-\frac{1}{a}$, and putting a equal to 2, we have $\frac{1}{k}=2_1+273$, in which either k or t being given the other can be determined. (*J. Chem. Soc.*, April, 1884, XLV, 135; *J. Soc. Phys. Chim. Russe*, XVI, 232; *Nature*, August, 1884, XXX, 396.)

De Heen, assuming that the molecules of a liquid attract each other in the inverse ratio of the seventh power of their distance, and that the work done by the molecular forces during expansion through 1° in temperature is a constant for the same liquid, has given the formula $\frac{dV}{dt}=aV^{2.333}$ as true for the volumes of all liquids. In this formula a represents the expansion coefficient at 0°. The author has compared the values of $\frac{dV}{dt}$ calculated by this formula with those deduced from the empirical formulas of other authors, especially Kopp and Is. Pierre, and finds a satisfactory agreement. (*J. Phys.*, December, 1884, II, III, 549.)

Thoulet has suggested a very simple method of determining the volume expansion-coefficient of solid substances in small fragments. For this purpose he uses a solution of mercuric iodide in potassium iodide, of specific gravity from 2.75 to 2.85, the coefficient of which has been accurately determined by Goldschmidt. The solid is placed in the solution, and water is added until it remains in equilibrium, having the same density as the liquid. The temperature and density are noted. A small quantity of the concentrated solution is now added, and the solid rises to the surface. The density is again noted. Then the temperature is slowly raised, the liquid expanding more than the solid, until the temperature is reached at which the solid is again in equilibrium. Noting the final density of the liquid and its temperature, the

data are at hand for the calculation of the coefficient of the solid. (*C R.*, March, 1884, xcviii, 620.)

As long ago as 1867 Govi had propounded the hypothesis that the contraction which takes place when stretched rubber is heated was due to the expansion of the gas contained in its pores. When the caoutchouc is stretched the spherical cavities elongate; and on heating, the gas dilates more than the solid, and tends to make the ellipsoidal cavities spherical again, thus shortening the rubber. Hesehus has tested this hypothesis by performing the experiment in vacuo. Placing the stretched caoutchouc under an exhausted receiver, the expansion of the air due to diminished pressure should have the effect of shortening the rubber. But not the smallest effect was observed. (*J. Soc. Phys. Chim. Russe*, xv, 103; *J. Phys.*, October, 1884, II, iii, 459.)

Fromme has made an investigation into the changes produced in the molecular condition of iron by heating to redness and cooling. He concludes that in the tempering of a steel bar, besides the mechanical and purely physical process of sudden contraction, another change, also of a chemical nature, takes place, this consisting in a combination between the free carbon and the iron. (*Phil. Mag.*, December, 1884, xviii, 473.)

Gernez has studied the duration of the solidification of surfused sulphur in both the prismatic and octahedral forms, and finds that the time required for the latter to solidify is much longer, in some cases 100 times, than the former. During these experiments he succeeded in obtaining a third form of crystal, in long prismatic rods with a nacreous luster. Hence he concludes that the measurement of the velocity of solidification constitutes a new method of investigation, which applied to sulphur developed some unexpected facts, such as the modifications produced at constant temperature under the prolonged influence of heat, and the order of transformation under various conditions. (*J. Phys.*, II, iii, 58, 286, February, July, 1884.)

E. Wiedemann has experimented to determine the change in volume which metals and their alloys undergo on fusion. He used a thermometer containing the metal to be examined, in the form of a cylinder, surrounded with oil. The points of solidification were determined by the method of cooling. Zinc melts at 226° and increases in volume at the moment of fusion, this increase being from 1.7 to 2.2 per cent., according to the specimen. Plumber's solder increases in volume also about 2 per cent. Lead-bismuth alloys of various compositions show two different points of fusion, to each of which corresponds a notable increase of volume, but which, however, is not sudden. (*Wied. Ann.*, xx, 228; *J. Phys.*, II, iii, 148, March, 1884.)

Raoult has examined the laws of congelation in solutions, and confirms essentially the principles established by Blagden in 1788. The conclusion reached is enunciated in the following general law: A molecule of any compound whatever, in dissolving in 100 molecules of any liquid whatever, different in character, lowers the solidifying point of

this liquid by a quantity nearly constant, which is not far from 0.63°. (*J. Phys.*, January, 1884, II, III, 16.)

Guthrie has given the name *eutexia* to the property possessed by certain compound bodies of fusing at very low temperatures, such bodies being called eutectic bodies or eutectics. He uses the term for bodies made up of two or more constituents, which constituents are in such proportion to one another as to give the resulting compound body a minimum temperature of liquefaction. Taking up metallic alloys, he finds that the eutectic alloy of bismuth with lead contains 44.42 of lead and fuses at 122.7°; with tin, 53.90 per cent. of tin and fuses at 133°; with cadmium, 40.81 per cent. Cd, melting at 144°; and with zinc, 7.15 per cent. of zinc, fusing at 248°. A tetra-eutectic alloy, containing 47.38 of bismuth, 19.36 of lead, 13.29 cadmium, and 19.97 of tin, fused at 71°, below the temperature of boiling alcohol. His next experiments were made with salt alloys. With niter, fusing at 320°, the eutectic alloy with potassium sulphate fused at 300°, with potassium chromate at 295°, with barium nitrate at 278, with strontium nitrate at 258°, with calcium nitrate at 251°, and with lead nitrate at 207°. The analogy between eutectic alloys of this sort and cryohydrates is pointed out, and the geological and mineralogical importance of eutexia is discussed in the original paper. (*Phil. Mag.*, June, 1884, V, XVII, 462; *Nature*, June, 1884, XXX, 139.)

Trouton has compared together the quantities of heat necessary to evaporate at constant pressure quantities of different liquids taken in the ratio of their molecular weights, and finds that the amount of heat required by any body is approximately proportional to its absolute temperature at the point of ebullition. By multiplying the latent heat by the density, the amount of heat required to evaporate a quantity of a body proportional to its molecular weight is obtained; and the ratio of this value to the absolute temperature of the boiling point is approximately constant. Thus, the latent heat of bromine is 45.9, it boils at 63°, and its density is 79.75. Hence, $\frac{45.9 \times 79.75}{273 + 63} = 10.89$. The latent heat of butyric acid is 114.7, it boils at 162°, and its density is 44. Hence, $\frac{114.7 \times 44}{273 + 162} = 11.59$, a nearly identical value. The author concludes that the molecules of bodies, and especially of chemically related ones, in changing from the gaseous to the liquid state at the same pressure, disengage quantities of heat which may be called the molecular latent heat, directly proportional to the absolute temperature of the boiling point. (*Phil. Mag.*, July, 1884, V, XVIII, 54.)

Klobakow has devised an instrument for determining the vapor density of bodies of high and of low boiling points, respectively. For low boiling points the apparatus (which he calls a vapor-density dilatometer) resembles a weight thermometer. For bodies of high boiling point he uses an apparatus resembling an araometer, consisting of a

glass vessel with an opening at its lower part, which allows a part of the liquid in the instrument to flow out as the vapor in the upper portion expands. By means of a weighing apparatus the pressure of the inclosed vapor is ascertained. The results seem to be satisfactory. (*Wied. Ann.*, XXI, 466; *Am. J. Sci.*, November, 1884, III, XXVIII, 390.)

Meunier has modified the apparatus of Crafts and Meyer so as to obtain with it, under greatly reduced pressure, the vapor density of certain additional products of benzene which decompose at their boiling point under the ordinary pressure. The results given agree closely with theory. (*C. R.*, XCVIII, 1268, May, 1884.)

Clark has described an apparatus for the purification of mercury by distillation, which differs from those hitherto suggested chiefly in being supplied with the mercury to be distilled from a movable reservoir in the form of a constant-level regulator, the raising of which fills the distiller with mercury, thus rendering unnecessary a Sprengel pump to start the operation. The apparatus described will distill about two pounds of mercury in an hour. (*Phil. Mag.*, January, 1884, V, XVII, 24.)

Many experiments have been made on the liquefaction of the so-called permanent gases. Wroblewski has produced liquid oxygen in such quantities as to use it as a refrigerating agent. When liquefied in large quantity and allowed to evaporate briskly by the sudden removal of the pressure, it does not solidify like carbon dioxide, though it deposits a crystalline residue. Hitherto he has not found it possible to obtain oxygen in a stable liquid condition under the pressure of one atmosphere. Hence the objects to be cooled must be placed in the apparatus, which is then filled with the liquid oxygen. By means of a thermo-electric apparatus, controlled by a hydrogen thermometer between 100° and —130°, the author estimates the temperature produced by boiling oxygen at —186°. When nitrogen is compressed, cooled in boiling oxygen, and then slightly released from pressure, it solidifies and falls like snow, in crystals of remarkable size. (*Phil. Mag.*, February, 1884, V, XVIII, 158; *Am. J. Sci.*, April, 1884, III, XXVII, 319.)

Dewar, in a lecture at the Royal Institution, produced and experimented with 1.5 c. c. of liquid oxygen, prepared by an apparatus of great simplicity. In an iron reservoir oxygen is compressed to 150 atmospheres. A copper tube, on which is a manometer, connects this reservoir with a glass tube 5^{mm} diameter and 3^{mm} thick, in which the liquefied gas collects. This is inclosed in a glass tube containing the liquid ethylene, solid carbon dioxide, or liquid nitrogen monoxide, which is to be boiled in vacuo as the refrigerant. Outside of this is a larger tube, through which the cold vapors pass on their way to the air-pump. When the pump has reduced the pressure to 25^{mm}, the ethylene has a temperature of about —140°; and then a pressure of between 20 and 30 atmospheres is sufficient to produce liquid oxygen in the tube. When solid CO_2 is used, a temperature of —115° is obtained; and with liquid N_2O, one of —125°. As the critical point of oxygen is —113°, both

these refrigerants enable the condensation to liquefy the oxygen, provided the pressure is above 50 atmospheres. But it is convenient to have a stop-cock attached to the tube, whereby a sudden expansion may be effected and a lower temperature thus obtained. By knowing the volume of the liquid oxygen and the corresponding volume of the gaseous oxygen, the density of the liquid may be obtained. A rough experiment gave Dewar 0.65 as the density near the critical point. As early as 1883 Dewar had made experiments on liquefied marsh gas, and pointed out the fact that the ratio of the critical temperature to the critical pressure is proportional to the molecular volume. Hence, since the critical temperature of marsh gas is less than $-100°$, and its critical pressure only 39 atmospheres, he believed he could approach the absolute zero by its evaporation. In his paper he gives a valuable table of the critical temperature, the critical pressure, and the ratio of the two for 21 gases, in parallel columns. (*Phil. Mag.*, September, 1884, V, XVIII, 210.)

Olszewski, using a hydrogen thermometer, has shown that under a pressure of 1 atmosphere oxygen boils at $-181°$, and that when it evaporates under a pressure of 6^{mm} of mercury the temperature is $-198°$. But even this latter temperature was not sufficiently low to liquefy hydrogen, being above its critical temperature. Recourse was therefore had to nitrogen. This gas, under a pressure of 60 atmospheres, cooled to $-142°$ by ethylene boiling in vacuo, liquefied, but showed no meniscus. On diminishing the pressure to 35 atmospheres, the nitrogen boiled so rapidly that it appeared white and opaque in the upper part of the tube. Keeping the pressure at this point, the boiling ceased, the liquid became clear and showed a well-pronounced meniscus. About 3 or 4 c. c. of liquid were obtained, which evaporated slowly, increasing the pressure until it reached 39.2 atmospheres, the critical pressure, when the meniscus disappeared. Exposed to the atmospheric pressure the liquid evaporated at first rapidly, then more slowly, the liquid remaining transparent, with no trace of the crystals observed by Wroblewski. Indeed, by no sudden expansion could it be frozen. But when a sudden expansion was produced with hydrogen in a tube placed within the liquid nitrogen, the pressure falling from 160 to 40 atmospheres, the hydrogen condensed as a colorless and transparent liquid, running down the walls of the tube. An instant after, the outside of this tube became covered with a white, opaque layer of solidified nitrogen, produced by the intense cold given by the boiling hydrogen. Subsequently Olszewski employed liquid ethylene under a pressure of 10^{mm} of mercury and obtained a temperature of $-150°$. He studied the temperatures obtained at various pressures, as follows: At 750^{mm}, $-103°$; at 546^{mm}, $-105°$; at 441^{mm}, $-108°$; at 346^{mm}, $-111°$; at 246^{mm}, $-115.5°$; at 146^{mm}, $-122°$; at 107^{mm}, $-126°$; at 72^{mm}, $-129.7°$; at 56^{mm}, $-132°$; at 31^{mm}, $-139°$; at 12^{mm}, $-148°$; and at 9.8^{mm}, $-150.4°$. At this latter temperature the liquefaction of several cubic centimeters of nitrogen presents no difficulties, it being

entirely unnecessary to use liquid oxygen. Studying nitrogen as above, he obtained the following values of pressure and temperature: At 35 atmospheres (the critical pressure) the temperature was $-146°$ (the critical temperature); at 31 atmospheres $-148.2°$; at 17 atmospheres $-160.5°$; at 1 atmosphere, -194.4; and in vacuo, $-213°$. This, then, was the temperature actually attained in the experiments with hydrogen above described. The author differs from Wroblewski, since with oxygen boiling under a pressure of only one atmosphere, and even under an expansion of 100 atmospheres, he obtained no trace of liquefaction with hydrogen. Indeed, it was only with oxygen boiling in a vacuum, and hence giving a lower temperature by 17°, and under expansion of the gas compressed to 190 atmospheres, that the first trace of liquefaction appeared. The liquid hydrogen enabled Dumas to say that it certainly was not a metal, as many had been led to believe it would be. It was a colorless, transparent liquid. Continuing his researches, Olszewski next used air as the refrigerant, having obtained 6 c.c. of it. The air was compressed in Natterer's apparatus and allowed to pass into a glass tube cooled to $-142°$ to $-150°$ by means of ethylene. No meniscus was observed at 50 atmospheres, although this is superior to the critical pressure. On diminishing the pressure to 37.6 atmospheres, the air began to boil and the meniscus appeared at once. This pressure is below the critical pressure, the meniscus disappearing at 39 atmospheres. The following are the observed values of pressure and temperature for air: At the pressure of 39 atmospheres the temperature was $-140°$ (the critical point); at 33 atmospheres, $-142°$; at 27.5 atmospheres, $-146°$; at 20 atmospheres, $-152°$; at 14 atmospheres, $-158.5°$; at 12.5 atmospheres, $-160.5°$; at 6.8 atmospheres, $-169°$; at 4 atmospheres, -176; at 1 atmosphere, $-191.4°$; and in vacuo, $-205°$. Since the temperature under which air boils in vacuo, calculated from that of oxygen, $-198°$, and nitrogen, $-213°$, differs considerably from $-205°$, it would seem that when air is liquefied the relative proportion of its constituents is not preserved. (*C. R.*, April, 1884, XCVIII, 913; July, 1884, XCIX, 133, 184.)

Olszewski has liquefied carbon monoxide also, and has studied its properties. The gas was carefully purified from carbon dioxide, and compressed to 70 atmospheres in Natterer's pump, from whence it passed to the apparatus used in liquefying oxygen and nitrogen. The following values were observed: Under the pressure of 35.5 atmospheres the temperature was $-139.5°$ (the critical temperature); at 25.7 atmospheres, $-145.3°$; at 23.4 atmospheres, $-147.7°$; at 21.5 atmospheres, $-148.8°$; at 20.4 atmospheres, $-150.0°$; at 18.1 atmospheres, $-152°$; at 16.1 atmospheres, $-154.4°$; at 14.8 atmospheres, $-155.7°$; at 6.3 atmospheres, $-168.2°$; at 4.6 atmospheres, $-172.6°$; at 1 atmosphere, $-190°$; and in vacuo, $-211°$, the solidifying point. At temperatures between $-139.5°$ and $-190°$ liquid carbon monoxide is colorless and transparent. In vacuo the temperature falls to $-211°$, and it solidifies either in a snowy mass, if the vacuum is rapidly made, or a compact, opaque mass, if the

process be slow. If it be so slow that the evaporation is allowed to take place from the surface only, the solid mass is entirely transparent Increasing the pressure to 1 atmosphere liquefies it. (*C. R.*, October, 1884, XCIX, 706.)

In hygrometry, Jamin has called attention to the unsatisfactory character of the ratio $\frac{f}{F}$, f being the elastic force of the vapor as observed and F the maximum tension for that temperature, this ratio being called the relative humidity, to express the quantity of vapor in the air. This ratio varies with the proportion of vapor in the air, with the altitude and the barometric pressure, and with the temperature. He therefore proposes the ratio $\frac{f}{H-f}$, which measures the hygrometric composition of the air. This value he calls the hygrometric richness. (*J. Phys.*, November, 1884, II, III, 469.)

Crova has pronounced in favor of the Saussure hair-hygrometer, and says that, well made and with a good table of calibrated values, it will give very satisfactory results, entirely comparable with those of other instruments. He gives in his paper the details of a plan of graduating absorption instruments, which is simple and apparently accurate. (*J. Phys.*, September, 1884, II, III, 390.)

Pernter has made a series of psychrometrical observations on the Obir, 6,722 feet above the sea-level, using Wild's ventilation-hygrometer, Regnault's dew-point hygrometer, and Schwackhofer's volumetric hygrometer. The general result obtained is that an exact formula for the psychrometer can scarcely be obtained, and that therefore we cannot expect by means of the psychrometer to determine the pressure of vapor to within 0.1^{mm}. (*Beiblätter der Physik*, VIII, 31; *Phil. Mag.*, May, 1884, V, XVII, 412.)

LIGHT.

1. *Production and Velocity.*

Lecher has made an experiment to determine whether the velocity of light is affected by the motion of a current in the medium. A beam of light was divided into two parts, which, after passing through two parallel glass troughs, were united by an interference prism, giving the usual fringes. The troughs contained a strong solution of silver nitrate, and, by means of suitable silver electrodes, an electric current of six amperes strength was carried in opposite directions through the trough, so that in one the electric current flowed in the same direction as the light, and in the other in the opposite direction. But in no case was any displacement of the fringes observed. Hence he concludes that the velocity of light is not influenced by a current flowing through the medium. (*Nature*, XXIX, 559, April, 1884.)

At the Electrical Congress held in Paris in April it was decided to adopt the light emitted from a square centimeter of platinum at its

melting point as the photometric standard. This standard was suggested by Violle, who has made many experiments, first with silver and subsequently with platinum. Having assured himself that the radiation from silver was constant during solidification, he proposed as the absolute unit of light the radiation emitted by a square centimeter of surface of melted platinum at the temperature of solidification. The platinum must be perfectly pure and must be melted in a lime crucible. By means of a diaphragm blackened on its surface, having a square opening, it is easy to obtain a beam of definite cross-section. When the measurement is to be made, the gas is shut off and the liquid metal is allowed to cool. This, which is at first rapid, becomes slower and slower, becoming finally stationary. Then a "lightening" passes over the surface, and the cooling continues. The moment of measurement is at the instant when the temperature is stationary. By continuing the flow of gas, instead of cutting it entirely off, this point may be preserved for a longer time. The author has compared the light thus radiated with that of a standard carcel lamp, first, when the light was emitted by the platinum at an angle of 45°, and, second, when it was emitted normally and reflected from a mirror at 45°. The photometer used in the first comparisons was the Rumford instrument, as used in the light-house service; in the second, besides this instrument, a Foucault photometer was used, of the form used in testing officially the gas supplied to Paris. By the first method the light emitted by the platinum was 2.118 carcels; by the second, 2.079 for series 1, group A, and 2.077 for group B, series 2 giving 2.077. The mean of the whole is 2.08 carcels. Assuming the flame of the carcel lamp to have 5.25 sq. cm. of surface, an equal surface of platinum would emit 2.08×5.25, or 10.92 carcels. The intrinsic intensity of the platinum standard is then 11 times that of the carcel lamp. Comparisons were also made with a Swan incandescent lamp, the light emitted by it under known current conditions having been carefully determined. The mean of these comparisons gave 2.069 carcels. (*C. R.*, April, 1884, XCVIII, 1032; *J. Phys.*, June, 1884, II, III, 241; *Phil. Mag.*, June, 1884, V, XVII, 563; *Am. J. Sci.*, July, 1884, III, XXVIII, 72.)

Werner Siemens has contrived an apparatus for putting the above unit into practice, although it determines the light emitted by platinum at its melting point and not at its solidifying point. A very thin platinum plate is inclosed in a metallic case provided with a hole 0.1 sq. cm. in section, which is immediately over the metal. The sides about the hole are inclined toward it, the platinum plate being considerably larger. At the instant of melting, the light radiated through the opening is 0.1 of the standard. By suitable arrangements the current may be modified and controlled so as to produce the melting at will when the comparison is to be made. Preliminary experiments show that the light emitted is about 1.5 standard candles. (*Wied. Ann.*, XXI, 304; *Am. J. Sci.*, August, 1884, III, XXVIII, 150.)

Weber has described a photometer depending upon equal visual acuteness, the two sources of light which are to be compared being made to illuminate two similar halves of a glass plate on which are photographed concentric circles very close together. The advantage claimed for this method is the facility which it gives of comparing a diffuse light with a standard, or even two lights of different colors with one another. In the latter case the observation is facilitated by the use of a red glass. (*Wied. Ann.*, XX, 326; *J. Phys.*, March, 1884, II, III, 143.)

Wild has shown that his polarizing photometer may be converted into a spectrophotometer by interposing an Amici prism between the double-image prism and the polariscope. The slit is placed close to the terminal faces of the total-reflection prisms. A collimating lens is placed against the Foucault prism. Under these conditions each of the sources of light shows a channeled spectrum, the bands being alternate in the two. Hence when the spectra are superposed, the fringes disappear for one particular portion of the spectrum. A slit attached to the eye-piece, movable by a micrometer screw, serves to limit the region in which the measures are taken. (*Wied. Ann.*, XX, 452; *J. Phys.*, March, 1884, II, III, 142.)

Crova has pointed out that the complete determination of the photometric value of a powerful light requires: first, a comparison of two lights of differing colors; second, an estimation of the color by means of a numerical factor; and, third, the determination of the photometric ratio between a very intense light and a relatively feeble standard. The first point he solves by the use of a solution consisting of 22.321 grams of ferric chloride and 27.191 grams crystallized nickel chloride, dissolved in distilled water to a volume of 100 c. c. at 15°, which is placed between the eye and the screen. A thickness of 7^{mm} of this solution allows rays of wave-length 630μ to 534μ only to pass, the limiting value being 580μ which is the best for solar photometry. The second point is attained by making two successive determinations by means of the spectrophotometer—one through the above solution, giving the intensity ratio; the other through a red glass colored with cuprous oxide, which allows rays from 726μ to 752μ to pass, and which gives a ratio as much below the former one as the light is whiter than the carcel. The quotient of the first ratio by the second is a constant which fixes the color, having a higher value as the light is whiter, and is equal to unity when the light has the same color as the carcel. For an incandescent lamp it varies from 1.05 to 1.23, and for the arc 1.5 to 1.7. The third point requires a special photometer. (*C. R.*, December, 1884, XCIX, 1067.)

Crova has subsequently described this instrument, which he calls a diffusion photometer. On a plate of ground or of opal glass, or on a Foucault screen, acting as a diffuser, a uniform luminous field is thrown, the incident rays falling normally. Each of the points of the plate may be considered as a luminous source, and sends back of the screen an amount of light depending on the character of the screen and varying

with the angle of emission, though in a nearly normal direction the rays have the same intensity. Behind the diffuser an opaque screen is fixed, furnished with a variable slit. The amount of light passing through this opening is proportional to the extent of the luminous field covered by it, to a coefficient depending on the diffuser itself, to the area of the opening, and to the inverse square of the distance. By means of such a photometer the author has determined the sun's light to be equal to 7,500 carcels, that of the Serrin lamp used by him being 230 to 320 carcels. The coefficient of his diffuser is the value in carcels of the field in which the diffuser should be placed in order that 1 sq. cm. of its surface should emit the light of one carcel. Thus a ground glass of 400 carcels is a glass 1 sq. cm. of which placed in a field of 400 carcels emits a light of 1. (*C. R.*, December, 1884, XCIX, 1115.)

McLeod has proposed a new sunshine-recorder, consisting of a camera so fixed that its axis is parallel to the polar axis of the earth, the lens pointing northward. Opposite the lens a silvered sphere is placed, from which the rays of the sun are reflected through the lens of the camera on to the sensitive paper, on which a distorted image of the sun is formed, the positions of the lens and sphere being so arranged that the image is a linear and radial one. By the motion of the earth the solar image is carried over a circular arc, and traces a curve on the sensitive paper. The ordinary ferricyanide paper is employed, and the instrument is sufficiently sensitive to register gleams of sunshine and also the passage of small clouds. Radial lines are drawn from the center of the circular band, 15° apart, to serve as hour lines. (*Phil. Mag.*, August, 1884, V, XVIII, 141.)

2. *Reflection and Refraction.*

Basso has studied the phenomena of reflection from crystalline surfaces, using a Bunsen photometer illuminated on one side by sunlight which has traversed orange-yellow glass, and is polarized in a suitable azimuth by means of a Nicol prism, reflected to the screen from the crystalline face to be studied, the other side receiving the light from a disk of ground glass, illuminated by a petroleum lamp. The crystal used was a plate of Iceland spar, cut perpendicularly to the axis. The intensity of the light reflected from the spar was calculated for various angles of incidence and for various azimuths of polarization. For azimuth 0 the formulas become those of Fresnel. Assuming the value for this azimuth and rotating the Nicol, the intensity may be determined for various azimuths by varying the distance of the lamp from the disk. The results are in fair accord with theory. (*Il Nuovo Cimento*, XIV, 5; *J. Phys.*, December, 1884, II, III, 558.)

Conroy has communicated to the Royal Society the results of his measurements of the amount of polarized light reflected by metallic surfaces. He used mirrors of steel and of speculum metal, highly polished, the incident light being polarized by a Nicol prism. The experi-

ments appear to show that the generally received formulas for metallic reflection are approximately correct, but that the actual intensity of the reflected light is always less than the theoretical intensity. Hence, unless the surfaces be defective, these formulas do not express the laws of metallic reflection. If, as appears to be the case, a change in the reflective power of a plate can occur without any change in the values of the principal incidence and azimuth, the formulas must be regarded as only approximately true, and there is additional reason for thinking, with Stokes, that three constants are required to define a metal optically. (*Nature*, February, 1884, XXIX, 398.)

Gouy has studied the light diffused from depolished glass and metal surfaces. The apparatus consisted of a mirror and attached polarizer, by which a beam of light polarized in any plane could be thrown at any incidence upon the roughened plate, placed horizontally. The diffused light was observed by means of a polariscope. Taking a plate of ordinary ground glass, the incident ray being polarized in a plane perpendicularly to the plane of incidence, and the angle of incidence being 60°, he finds that there are two neutral directions, making an angle of 47° with the normal to the plate and symmetrically situated with reference to plane of incidence, so that that plane which contains either of them and the normal makes an angle of 22° with the plane of incidence. On the one side of the incident plane the light is circularly or elliptically polarized in the right handed direction, and on the other side left-handed, while in the plane of incidence it is plane polarized. If, however, the incident light is polarized in the plane of incidence, the two neutral directions still exist, and are symmetrical with reference to this plane, but are otherwise quite different from those just described. The two angles are 77° and 95°, respectively, and the gyration of the rays is inverted, so that the right and left handed rays have changed sides. (*C. R.*, April, 1884, XCVIII, 978.)

Dufet has examined the influence exerted by temperature on the refractive index of quartz, studying, first, the variation of the double refraction, and, second, the variation of the ordinary and extraordinary indices. The quartz used was a rectangular parallelopipedon, 14.07^{mm} in the direction of the axis and 14.614^{mm} in the perpendicular direction. The refractive indices taken were those of Mascart, and the expansion coefficients those of Benoit. The variation of the double refraction was measured by the displacement of Fizeau's and Foucault's fringes, and that of the two indices by the displacement of Talbot's bands. He finds that the indices of both rays diminish with the temperature by values considerably above those of Fizeau. (*C. R.*, May, 1884, XCVIII, 1265; *J. Phys.*, June, 1884, II, III, 251.)

Bauerwald has determined the refractive indices of rutite, the specimen being a remarkably transparent crystal from Syssert, in the Ural, cut into a prism of 25°. The ordinary index for the lithium line was 2.5671, for the sodium line 2.6158, and for the thallium line 2.6725. The

extraordinary index for these three lines was 2.8415, 2.9029, and 2.9817, respectively. The only minerals having higher indices are zigueline, red silver, and cinnabar. (*Zeitschr. Kryst. & Min.*, VII, 167; *J. Phys.*, February, 1884, II, III, 105.)

Soret has determined the refractive indices of the alums for the eight principal lines of the spectrum. He used seven alumina alums, four chrome alums, five iron alums, two gallium alums, and an indium alum. (*C. R.*, November, 1884, XCIX, 867.)

Quincke has investigated the change which takes place in the volumes and refractive indices of liquids when subjected to hydrostatic pressure. The liquids were contained in glass or metal tubes 230^{mm} long, which were placed in an interference apparatus. One of the two interfering pencils traversed the liquid, and by measuring the number of interference bands which corresponded to a given Fraunhofer line, before and after the pressure was applied, the change in the index could be calculated. He draws the conclusion that at constant temperature and varying hydrostatic pressure, the specific refraction, at least for the liquids examined, which is $n - 1 \div \sigma$, is equal to a constant; in other words, the decimals of the refractive index are proportional to the density. (*Phil. Mag.*, January, 1884, V, XVII, 65.)

Shaw has described a means of verifying the phenomena of refraction by the prism, especially the focal lines, by using a piece of wire gauze as the object, placed so that one set of wires is horizontal and the other vertical, and illuminated by a sodium flame behind it. If the light pass directly from the gauze to the prism, the focal lines are of course virtual, but they may be easily viewed and their positions identified by means of a telescope which will focus an object at a short distance. For one position of the eye-piece of the telescope the vertical wires are seen distinctly, but not the horizontal wires; while for another position these latter may be seen, but the former ones are not visible unless the prism is at minimum deviation. The experiment is more striking if the focal lines be made real by interposing between the gauze and the prism a convex lens of somewhat long focus. The vertical and horizontal images may then be viewed by means of an ordinary magnifier, or, better, by a telescope eye piece placed behind a second gauze, with its wires at 45° to the vertical. In this way the images corresponding to the two focal lines can be seen very clearly, and their distances from the prism accurately measured. If the prism be placed first in the position of minimum deviation, and the magnifier be focused upon the image of the gauze, both horizontal and vertical wires are seen sharply defined. On gradually turning the prism the vertical lines disappear completely. If the eye-piece be drawn back some way, a badly defined image of the gauze can be obtained, corresponding to the circles of least confusion; and on withdrawing the eye-piece still farther, the horizontal wires disappear entirely, while the vertical ones come out sharply as a set of bars across a uniform field. (*Nature*, December, 1884, XXXI, 185.)

Haycraft has described the model of a lens which he has used successfully in his lectures. It consists of a piece of deal board cut in the shape of the cross-section of a double-convex lens, and mounted so as to stand vertical. Four small squares of board are fixed on the two sides of this model, near the top and bottom, so that they can move about a center. To each of these a glass tube bent at an obtuse angle is fastened, and strings passing through these tubes represent the visual rays. (*Nature*, October, 1884, XXX, 543.)

3. *Dispersion and Color.*

Demarçay has pointed out the advantage of employing in spectrum work an induction coil having a shorter and larger secondary wire than is usual. His coil gives a spark only about 5^{mm} long, though it is 11.5^{cm} in diameter and 23^{cm} long. The primary and secondary wires are both 1^{mm} in diameter, but the latter is nearly three times as long as the former and the coil has three times the usual condensing surface. The spark, though short, is quite thick, its aureole being 3^{mm} in diameter. For the examination of liquids the author uses a sort of wick made of platinum wires twisted together and then rolled into a circle, with one end rising out of the middle. This is placed in the small dish containing the solution to be examined, and the spark, which need not be more than one fourth to one-half a millimeter, is passed to the upright end from a positive electrode of large wire. (*C. R.*, December, 1884, XCIX, 1022, 1069.)

Thollon has published an illustrated monograph of the line, or rather the group, D of the solar spectrum, as observed with his new compound prism. He gives for comparison the group as observed by Huggins in 1863, by Campbell in 1865, by Russell in 1877, by Vogel in 1879, by Gassiot in 1863, by Cooke in 1866, by Fiévès in 1882, and by Cornu in 1884. The last two were obtained by means of a Rutherfurd grating. The author's spectroscope separates the components proper of the line D by 12 minutes. Between these extremes this instrument shows twelve sharply defined lines, the wave-lengths of which are given. Of these nine are telluric, produced by some variable constituent of our atmosphere, moisture probably. Two are not telluric, the one belonging to nickel, the other to an unknown element. The last seems to possess the characteristics of both, and hence the author concludes must be made up of two components superposed, one telluric, the other metallic. A drawing is given showing the appearance of this group, first, when the eastern limb of the sun is on the slit, and, second, when the western limb is so placed. The displacement of the solar lines and the non-displacement of the telluric ones are marked. (*J. Phys.*, January, 1884, II, III, 5.)

Cornu has published a valuable memoir on the group *a* of the solar spectrum, having devised an exceedingly ingenious method of distinguishing at a glance solar from telluric lines. On the slit of the col-

limator a small image of the solar disk is projected by means of an achromatic lens of 10 or 12 inches focus. On causing now this lens to oscillate rapidly two or three times per second, so as to bring the two opposite edges of the disk alternately on the slit, the lines of solar origin oscillate with the lens, while those which are telluric remain fixed. Moreover, a singular illusion appears: the trembling lines seem to stand out in relief, and to oscillate in front of the fixed ones. By means of this neat device the author has determined the group *a* to consist of three entirely distinct sets of lines: first, those which are solar, and of which twenty-five are figured; second, those which are due to the dry atmosphere (the structure and grouping of these lines strikingly recalls that of the groups A and B; and since Egoroff has shown these latter to be due to oxygen, it is probable that the former are due to the same element); and, third, lines due to aqueous vapor, of which only a few are given. (*J. Phys.*, March, 1884, II, III, 109.)

Thollon has also described and figured with minute accuracy the seventeen lines which constitute the group B of Fraunhofer, arranging them in four sections: First, when the sun is at 80° from the zenith; second, when the sun is 60° from the zenith, air damp; third, when the sun is 60° from the zenith, air dry; and, fourth, lines not of telluric origin. Egoroff's discovery that this group is due to oxygen mainly, disposes of most of the lines. The others are due to solar absorption and to atmospheric moisture. (*J. Phys.*, October, 1884, II, III, 421.)

Egoroff has exhibited before the physical section of the Russian Physico-Chemical Society the production of the Fraunhofer lines A and B by passing the rays from a calcium light through a layer of dry oxygen 20 meters long, under a pressure of 8 atmospheres. (*J. Phys.*, October, 1884, II, III, 467.)

Liveing and Dewar have investigated the production of spectrum lines of the metals developed by exploding gases. Observing the flash of a mixture of oxygen and hydrogen gases, exploded in a Cavendish eudiometer, in the spectroscope, the authors were struck with the brightness of the lines not only of sodium but also of calcium, and were thereby led to make a series of experiments in iron tubes, half an inch in diameter and 3 feet long, closed at one end by quartz plates held in place by means of a screw-cap. The stronger iron lines were distinctly seen, and so various substances in powder were introduced into the tube. In the case of lithium, when the mixture was fired at the remote end of the tube, so that the flame traveled toward the slit, the red line was reversed, a fine dark line being visible in the middle of the band; thus proving that there are gradations of temperature in the flame, the front of the advancing wave being somewhat cooler than the following part. Sixty iron lines in the indigo, violet, and ultra-violet developed in this way were photographed. Other metallic salts were introduced into the tube, and also other gaseous mixtures. (*Phil. Mag.*, September, 1884, V, XVIII, 161; *Nature*, April, 1884, XXIX, 614.)

H. Becquerel has examined the emission-spectra of metallic vapors in the infra-red region, making use of a suitable phosphorescent substance, previously rendered luminous by insolation, as the screen for receiving these spectra. Under the influence of the infra-red rays a temporary excitation preceding extinction is developed, and the lines otherwise invisible appear brilliant. Certain of these phosphorescent powders, notably calcium sulphide, were so sensitive as to allow the wave-lengths of the more brilliant lines of potassium, sodium, and cadmium to be determined at once by means of a Rutherfurd grating. In other cases the spectra were obtained by means of a carbon disulphide prism, the wave-lengths being determined by interpolation. The wave-lengths of 4 lines of potassium, 1 of sodium, 5 of strontium, 2 of calcium, 4 of magnesium, 2 of aluminum, 2 of zinc, 1 of cadmium, 5 of lead, 2 of silver, 2 of tin, and 1 each of bismuth and thallium are given. (*C. R.*, XCIX, 374, August, 1884; *Phil. Mag.*, October, 1884, V, XVIII, 386; *Am. J. Sci.*, December, 1884, III, XXVIII, 457.)

Becquerel has applied the same method to the investigation of the infra-red region of the solar spectrum. A beam of light reflected from a diffraction grating was concentrated by a lens and traversed a carbon disulphide prism whose sides were normal to the slit and the lines of the grating, and formed on the phosphorescent surface a series of oblique spectra, in which the radiations with spectra of different orders were juxtaposed and not superposed. The slit was so narrow that the principal lines of the luminous spectra could be seen, so that by comparing the lines and bands in the infra-red of the first spectrum with the known lines of the second and third their wave-lengths could be obtained. The author claims that this method allows of a further exploration than the photographic one, and is not exceeded by the bolometer or thermopile. Indeed, if the phosphorescent agent is sensitive, the details can be made out far better than with the bolometer. The wave-lengths measured are given in the paper. (*C. R.*, XCIX, 417, September, 1884; *Phil. Mag.*, November, 1884, V, XVIII, 465; *Am. J. Sci.*, III, XXVIII, 391, 459.)

Soret and Sarasin, members of a commission appointed by the Natural History Society of Geneva to study the properties of the water of their lake, have observed a distinct absorption band in its spectrum, which is visible when the light passes through a layer of the water only 2^m in thickness. This band is a little less refrangible than D, being located in the orange, about one-fifth the distance between D and C, corresponding to a wave-length of about 600. This band was observed in distilled water even when carefully purified by distillation with permanganate in a vessel of platinum. (*C. R.*, March, 1884, XCVIII, 624.)

Soret has published a later paper, in which the question of the color of water is discussed with especial reference to the color of the Lake of Geneva. (*J. Phys*, October, 1884, II, III, 427.)

Abney and Festing have shown that, when light traverses a thick-

ness of 2^{mm} of a solution of iodine in carbon disulphide containing 4 per cent. of iodine, a photograph of its spectrum proves the non-absorbed light to consist of two bands, one beginning near G and terminating in the ultra-violet, the other including the infra-red and extending to a point near D. As the richness of the solution in iodine increases up to 32 per cent., the former of these bands narrows from both ends, finally becoming a mere strip near *h*, while the latter contracts toward the red, the extreme red not being reached by the absorption. This solution, therefore, is very useful in the study of these regions of the spectrum. (*Proc. Roy. Soc.*, XXXIV, 480; *J. Phys.*, March, 1884, II, III, 145.)

The absorption of the ultra-violet rays by different media has been made the subject of investigation by several physicists. Liveing and Dewar employed as a source of light an induction spark between iron points, a condenser being in circuit, the iron lines furnishing points of reference. The prisms, lenses, and tanks used were of quartz or of rock salt, and the absorbing bodies tried were chlorine, bromine, iodine, sulphurous oxide, hydrogen sulphide, carbon disulphide and tetrachloride, chlorine tetroxide, chrome alum, mica, silver, gold, Iceland spar, &c. The spectra were photographed. (*Proc. Roy. Soc.*, XXXV, 71; *J. Phys.*, May, 1884, II, III, 218.)

Soret used a revolving spark-carrier, consisting of two disks, whose axes were at right angles, and whose circumferences carried different metals for producing the spark. The liquid whose absorptive effect was to be studied was contained in a glass vessel closed at bottom by a quartz plate, and the light of the spark, after being rendered parallel by a quartz lens, passed through this liquid, the thickness of which was varied by the immersion in it of a glass tube having quartz plates at the ends. Beneath this colorimeter was a spectroscope with a fluorescent eye-piece. After determining the thickness of a liquid required to extinguish any of the metal lines, the author constructed curves having the deviations of these lines as abscissas and the thicknesses of the layers as ordinates, and thus obtained curves for the comparison of the absorption of the substances used. (*J. Phys.*, July, 1884, II, III, 311.)

Atmospheric absorption has received considerable attention. Langley read a paper before the National Academy, in which he showed that the ordinarily assumed coefficient, about 20 per cent., was too low probably by an amount equal at least to the whole amount in question. The cause of this lies in the assumption by Bouguer's formula, employed by Herschel, Pouillet, and others, that the coefficient of transmission through the atmosphere is a constant. That this is impossible follows from the composite character of the radiation, as Melloni long ago proved. From his own reasoning, founded upon the best data he has been able to obtain, the author believes the actual mean absorption of sun and starlight to be not improbably over 40 per cent. at the sea level. (*Am.*

J. Sci., September, 1884, III, XXVIII, 163; *Phil. Mag.*, October, 1884, V, XVIII, 289.)

Abney and Festing, by photographing the infra-red solar spectrum under different atmospheric conditions, have shown that when the air is nearly saturated with moisture this part of the spectrum is covered by a dark band extending to wave-length 8330. In a very dry time the band extends only from wave-length 9800 to wave-length 9420. At a great altitude, with a cold northeast wind, this band disappears almost entirely, but can be reproduced by placing a suitable thickness of water before the slit. These photographs serve as indicators of atmospheric moisture. (*Proc. Roy. Soc.*, XXXV, 80; *J. Phys.*, May, 1884, II, III, 219.)

Nichols has studied the character of the light reflected from pigments by means of a spectrophotometer, in which one-half of the slit is covered by a right-angled prism, the other half by a Nicol prism, while the eye end of the observing telescope is furnished with a second Nicol and an adjustable diaphragm. By these means two spectra, one above the other, are produced, the lower one polarized in a vertical plane. In order to compare the spectrum of the light reflected by any object with the spectrum of daylight, the object is placed beneath the reflecting prism, and illuminated either by direct sunlight or diffused daylight. Skylight reflected through the Nicol gives the polarized spectrum, and by rotating the Nicol in the eye-piece it may be given any intensity required. Whatever be the character of the light reflected by the object to be studied, it is always possible to find a position of this Nicol for which any region of the spectrum under observation and the corresponding wave-length of the polarized spectrum are equally bright. Knowing the angle between the principal sections of the Nicols, the intensity of this region, in terms of the intensity of the corresponding wave-length in the spectrum of daylight, can be calculated. The author examined in this way red lead, chrome yellow, chrome green (chromic oxide), and artificial ultramarine, and gives the results in tabulated form and in the form of curves. (*Am. J. Sci.*, November, 1884, III, XXVIII, 342.)

Rosenstiehl has made a valuable contribution to the science of color in a little book published by the Société Industrielle of Rouen, intended to show the imperfection of methods founded on the study of coloring matters in distinction from those which recognize color simply as a property of matter, and, in the physiological sense, as simply an affection of the organ of sight. Attention is specially directed to the study of color by means of color sensations; and it is shown that it is to the analysis and synthesis of the retinal impressions that we are to look for exact views on the relationships of the colors. For the investigation of colors the author uses concentric disks rapidly rotated. These disks are divided into sectors of different magnitudes, variously colored. For the white disk barium sulphate is used, applied to a suitable sur-

face. It revolves in front of a small chamber lined with black velvet, and the proportion of black to white is determined by the size of the sector cut from the white disk. (*Nature*, November, 1884, XXXI, 58.)

Hoffert has devised a new apparatus for producing color combinations, which consists of a flat box irregularly hexagonal in shape, on one side of which six prisms are placed, arranged in two pairs and all set at the angle of minimum deviation. The first prisms have their refracting edges in contact, and, by means of a screen in which is a small rectangular aperture, small equal strips of the adjacent faces of these prisms are visible from an eye-piece which is simply a tube of brass in which is a slit one-tenth of an inch wide. If light entered through the eye-piece, each set of the prisms would deviate it about 150°, one to the right, the other to the left, and each beam would then fall on a lens of about 10 inches focal length, the two spectra thus produced being brought to a focus on the sides of the box immediately to the right and left of the eye-piece. At these points, on each side, are placed three incandescent wires; so that, conversely, if these be the sources of light, the rays follow an inverse course, and the corresponding half of the aperture in the screen is seen illuminated with a color which will depend on the position of the incandescent wire. (*Phil. Mag.*, August, 1884, V, XVIII, 81.)

4. *Interference and Polarization.*

Kissling has investigated the influence which foreign admixtures exert on the formation of fog in moist air, in the course of which he has observed a series of diffraction phenomena, the law of whose formation can only with difficulty be made to agree with Fraunhofer's law. He finds that in general the law of Aitken is true, and that when aqueous vapor is condensed in the air it always takes place on some nucleus. In the ordinary unfiltered air of a dwelling-room, when the space in which diffraction occurs is but slightly cooled, the fog is so strong that it greatly enfeebles even a powerful source of light. If this air be gradually admixed with filtered air, the formation of fog gradually diminishes, while at the same time phenomena of diffraction set in, the intensity of whose color increases until the quantity of vapor has sunk to a definite though extremely small amount. Small admixtures of sulphurous oxide and of ammonia with the unfiltered air of a room produce so strong a fog that any action of diffraction ceases. (*Phil. Mag.*, August, 1884, V, XVIII, 160.)

Madan has called attention to a simple method of producing the interference phenomena known as Ohm's fringes. Ohm himself directs that two plates of equal thickness are to be cut from a uniaxial crystal, their parallel surfaces making an angle of 45° with the optic axis. If now one of these be placed on the other in such a position that the optic axes lie in the same plane but upon opposite sides of the normal common to the two plates, and the combination be held in a convergent beam of

monochromatic plano polarized light, numerous alternations of bright and dark elliptical bands are seen, most distinctly when the plane containing the optic axes makes an angle of 45° with the plane of polarization of the light. Since in Iceland spar the natural faces of the rhombohedron make an angle of nearly 45° with the optic axis, Madan suggests the use of a simple cleavage plate, 2 by 1^{mm} in size and 2^{mm} thick, broken in halves, and one half turned round 180°, superposed on the other, and cemented with Canada balsam. On placing this on the eye-lens of a microscope, with the analyzer just above it, the ellipses will be well seen when sodium light is used. (*Nature*, November, 1884, XXXI, 83.)

Macé de Lepinay has shown that the graphic method of Cornu may be applied with great facility to the study of the diffraction fringes produced by an opaque rod, by means of an auxiliary curve, which is the same in all cases, since it is only the primitive spiral displaced parallel to itself by a fixed quantity. (*J. Phys.*, January, 1884, II, III, 11.)

Hartley has described a simple method of observing faint lines with diffraction spectroscopes. The operation is conducted in a darkened room, the goniometer of the spectroscope being illuminated by a shaded lamp placed on the right of the telescope. The grating is movable, the collimator and telescope being fixed so as to include as small an angle between them as possible. The telescope being to the right of the collimator, a small gas-jet is placed on the left, the rays of which are reflected into the telescope from the grating. By the adjustment of this light the field may be illuminated with any color of the spectrum, and by selecting that tint which is complementary to the color of the lines to be measured they are sure to stand out, apparently, in relief on a bright ground. (*Nature*, March, 1884, XXIX, 470.)

Mertching, under Egoroff's direction, has determined experimentally the focal distances for monochromatic light of a reflecting grating of Rutherfurd having 17,296 lines in an inch, for all incidences. In the spectra of the first and the second order the variations of the focal distances of the images situated to the right of the reflected image of the slit were inconsiderable, while those on the left were much greater and of contrary sign. The results, represented graphically, give a curve in which the focal distance is a function of the angle of deviation, and which the author regards as a variety of the hyperbola of the second degree. (*J. Phys.*, October, 1884, II, III, 459.)

Bucking has submitted crystals to pressure, with the view of determining the influence thus exerted on their double refraction. The crystal plate is placed on the stage of a polarizing microscope, pressure being exerted by a screw and measured by a dynamometer. In the case of apatite, for example, the angle between the axes, in the plane parallel to the direction of the pressure, but before the pressure was applied, was 3°. The plate used was 5^{mm} square and 4^{mm} thick, and the pressure varied from 0 to 100 pounds. The angle between the axes became

zero for a pressure of 6 pounds, equal to 10° for a pressure of 33 pounds, and to 17° for one of 100 pounds. After the removal of the pressure the angle between the axes was 5° in the primitive plane, and did not vary on repeating the experiment. Beryl gave no permanent variation. Vitreous orthoclase, whose axes are either in the plane of symmetry or perpendicular to it, shows, under pressure perpendicular to this plane, an increase of the angle in this plane and a decrease in the perpendicular plane. (*J. Phys.*, February, 1884, II, III, 106.)

Von Fleischl has communicated to the Vienna Academy the discovery of double-refracting liquids. The apparatus used was a compound hollow prism resembling, in general, Fresnel's quartz combination. Concentrated solutions of tartaric acid and of various sugars were employed, and also certain optically active oils. These doubly refracting liquids possess no optic axis, and the wave surfaces are in every instance two concentric spheres. (*Nature*, January, 1885, XXXI, 204.)

Röntgen has published a valuable memoir on the variation of the double refraction of quartz produced by electric force. Pressure experiments show that in a crystal of quartz of normal structure the surface of a section normal to the principal axis may be divided into six fields by lines intersecting at an angle of 60°. A pressure exerted in, any direction passing through this point develops contrary electricities at its extremities. When a fragment of quartz is submitted to electric induction, so that the lines of force, without being parallel to an axis of no pressure-electricity, are normal to the principal axis, the natural polarization is modified by the action of the electric forces, and at the same time the double refraction of the rays normal to the principal axis and to the lines of force is increased or diminished according to the direction of the lines of force. These results are of importance in connection with the theory of pyroelectricity proposed by Sir. W. Thomson. (*Wied. Ann.*, XVIII, 213; *J. Phys.*, January, 1884, II, III, 35.)

Two new forms of polarizing prism have appeared, one contrived by Feussner and the other by Bertrand. Sleeman has described the former, giving at the same time an illustrated account of the various polarizing prisms thus far proposed, six in number. The prism of Feussner consists of a thin plate of a doubly refracting crystal cemented between two wedge-shaped pieces of glass, the terminal faces of which are normal to their length. The refractive indices of the glass and the cementing medium should correspond with the greater index of the crystal, and the directions of greatest and least elasticity in the latter must stand in a plane perpendicular to the direction of the section. One great advantage of this prism is that other crystalline substances may be used instead of calc spar, provided the difference between the ordinary and the extraordinary index is greater than in calc spar. Feussner has used for this purpose a plate of sodium nitrate, whose indices are 1.587 and 1.336. In this, as in calc spar, cleavage plates may be used. As a cementing material a mixture of gum dammar with monobromnaphtha-

lene was used, having an index of 1.58. (*Zeitschr. f. Inst.-Kunde*, February, 1884, IV, 42; *Nature*, XXIX, 514, March, 1884.)

Bertrand constructs his prism by taking a prism of flint glass of index 1.658 and cutting it along a plane making an angle of 76° 43′ 8″ with the terminal faces. These new faces are polished and cemented with a substance of index equal or superior to 1.658, placing between these surfaces a cleavage prism of calc spar suitably adjusted. A ray of light falling on the prism enters it and is incident on the plate of calcite, which divides it into two, polarized in planes at right angles to each other. The ordinary ray, whose index is 1.658, continues its part in a direct line; but the extraordinary ray, whose index is less, does not enter the spar at all. In this way a polarizing prism is produced which has a field of 44° 46′ 20″. This prism closely resembles that of Feussner above described. (*C. R.*, September, 1884, XCIX, 538.)

ELECTRICITY.

1. *Magnetism.*

The magnetic moment of a bundle of iron wires has been frequently compared with that of an iron cylinder, but the influence of the diameter of the wire seems not to have been studied. Bakmetieff has filled the core of a cylindrical coil, 148^{mm} long and 32.2^{mm} in interior diameter, with iron wires of 1^{mm}, of 2^{mm} and of 5^{mm} diameter, and magnetized them by more or less intense currents. The magnetic moment of the bundle of the finest wires, as well as its specific magnetism, was notably superior to that of the two others, especially for intense magnetizing currents. But when, instead of filling all the space within the coil with the wire, only an annular layer of wire was placed within it, the specific magnetism of the fine wire, for the same current, was many times greater than that of the larger wires. (*J. Soc. Phys. Chim. Russe*, XV, 142; *J. Phys.*, October, 1884, II, III, 463.)

According to Auerbach, an iron cylinder free from magnetism receives from a magnetizing force a normal magnetic moment corresponding to that force, and which is measured by the current induced during its development. Bakmetieff now shows that this law does not apply to iron already possessing remanent magnetism. His experiments show that for electro-magnets not forming a closed magnetic circuit the normal magnetism has for its measure the arithmetical mean of the two induced currents obtained by closing the magnetizing circuit, directly and inversely. For a closed circular electro-magnet the normal magnetism has double this value. (*J. Soc. Phys. Chim. Russe*, XV, 173; *J. Phys.*, October, 1884, II, III, 464.)

Some time ago Quincke showed that electric force produces a pressure upon insulating liquids placed in an electric field. He has now extended his investigation to magnetic and diamagnetic fluids placed in a magnetic field. Calling the diamagnetic constant for air unity, he

finds that if the magnetic field is bounded by air the magnetic difference of pressure in the fluid and in the air may be expressed by a hydrostatic pressure, and thus its diamagnetic constant, less unity, can be measured. Using fields varying in strength from 300 c. g. s. to 12,000 c. g. s., the increase in height in some cases was more than 32^{mm} for magnetic fluids and -0.7^{mm} for diamagnetic ones. (*Ber. Ak. Berl.*, January, 1884; *Phil. Mag.*, June, 1884, V, XVII, 447; *Am. J. Sci.*, September, 1884, III, XXVIII, 223.)

Von Helmholtz has applied the ordinary chemical balance to the determination of magnetic moments. Even when the balance is itself not absolutely free from iron, values can be obtained which are constant and accurate to within a quarter of 1 per cent.; moreover, the most essential advantage of the method is that it is quite free from disturbances due to the incessant changes in the terrestrial magnetism. (*Ber. Ak. Berl.*, April, 1883; *Phil. Mag.*, January, 1884, V, XVII, 75.)

Wleügel and Henrichsen have examined the magnetism of some compounds of the alcohol radicals C_nH_{2n+1}, by placing them in long glass vessels suspended bifilarly between the pointed half armatures of a powerful electro-magnet, charged by the current from 16 to 18 Bunsen cells. The magnetism developed was measured by a torsion method by means of a mirror and scale. The conclusions are: (1) The introduction of CH_2 into the molecule produces an increase in the molecular magnetism which is nearly constant and has $-1,640$ for its mean value; (2) the molecular magnetism of a chemical body is equal to the sum of the partial magnetisms of the alcohol radical and of the other parts of the compound; (3) HO, I, S, and Br have the same specific magnetism, the mean value of which is -44.3; (4) Cl, on the other hand, has a different specific magnetism, about -61, a value nearly the same as that found for the radical of acetic acid, -63; (5) the alcohol radicals possess the same specific magnetism as their isomers; and (6) the magnetism of the alcohol radicals is made up of the atomic magnetisms of the carbon and hydrogen. (*Phil. Mag.*, July, 1884, V, XVIII, 78.)

Leduc has shown (*J. Phys.*, II, III, 133) that when a plate of bismuth is placed in a magnetic field at right angles to the lines of force, the equipotential surfaces of a current traversing the plate are deflected from their proper direction. Hence the physical condition of the metal must have experienced some alteration. Hurion has taken advantage of Kerr's observation that a mirror placed between the poles of an electro-magnet rotates the plane of polarization of an incident perpendicular ray when the magnet is excited, to test this change in the physical properties of bismuth. By pouring the melted metal on a hot plate of glass he prepared a mirror, which was placed between the poles of a Faraday's electro-magnet. It was found that the bismuth rotated the plane of polarization through 18′ in the opposite direction to the current which excites the magnet, and that its electric resistance is increased when it is placed in a magnetic field. (*Phil. Mag.*, October, 1884, V, XVIII, 389.)

Bosanquet has tested experimentally the idea of a repulsion between magnetic lines of force, by the use of rings magnetized by means of a continuous wire uniformly wound around them, and has shown that they present no external magnetic action even though they may be the seat of closed circuits of magnetic lines of force of very great intensity. Since we may suppose the ring divided into a number of separate rings, each containing lines of force, and since such rings will be wholly without action on one another, it follows that if such similar rings be placed parallel and close to each other they do not repel each other, as they should do if there existed a repulsion between parallel lines of force. (*Phil. Mag.*, December, 1884, V, XVIII, 494.)

McGee has described a novel magnetic engine, based on the diminution in the magnetism of iron by heat. It consists of a ring 13^{cm} in diameter, made up of one or more turns of iron wire and supported on radial arms so as to revolve about a vertical axis. Near it, and with its axis in a radial direction, is a permanent bar-magnet. If now the ring of wire be heated to bright redness on one side or the other of the magnet, this magnet exerts a stronger attraction upon the wire on the opposite or cooler side than upon the heated side, and the ring revolves. By means of a pulley and string on the axis, using a powerful electro-magnet, a weight of six grams was raised 50^{cm} in six minutes. The source of energy is of course the gas-burner employed. (*Science*, III, 274, March, 1884.)

Stracciati has studied the currents produced in iron by its demagnetization, and their influence upon the rapidity of this demagnetization, using for these experiments the method of Felici. He concludes that the rapidity with which the magnetism of a mass of iron disappears when the magnetizing force ceases, diminishes at first rapidly, when this force increases, but appears finally to tend toward a constant value; and that this velocity in the case of a bundle of iron wires separated by silk from each other diminishes notably when the mass is rendered a continuous conductor, as by plunging it in a bath of mercury. (*J. Phys.*, December, 1884, II, III, 552.)

Trowbridge and Hill have made an elaborate investigation of the heat produced in iron and steel by reversals of magnetization. Their conclusions are as follows: (1) The heat developed is probably due to induction currents and not to molecular vibrations; (2) the heating is confined to the surface until equalized by conduction; (3) the musical note emitted is the note of the coil, due to the number of reversals of the machine, and is merely strengthened by the metallic core; and (4) these experiments confirm what has long been known on the effect of vibrations and shocks on the magnetic condition of iron and steel. (*Am. J. Sci.*, January, 1884, III, XXVII, 58.)

Bakmetieff, who has also investigated these phenomena, arrives at the conclusion that magnetism by itself produces variations of temperature in magnetized bodies, and that this magnetic heat is equal to the

product of the magnetic moment by the magnetizing force multiplied by a constant, increasing with the frequency of interruption of the current, and still more when the current is alternated. (*Nature*, July, 1884, xxx, 223.)

Warburg and Hönig have also experimented in the same direction, and have come to the conclusion that a large proportion of the heat observed, nearly 75 per cent., is due to magnetic friction. (*Am. J. Sci.*, March, 1884, III, xxix, 238.)

2. *Electric Generators.*

Kalischer has tested the hypothesis that the condensation of steam may be a source of electrification, using twelve large glass vases covered with tin foil and filled with ice, placed on a sheet of tinned iron, insulated by a block of glass; the whole being placed within a large insulated metallic box, the metallic cover of which was perforated to allow the access of air. An insulated wire connected the sheet of iron on which the vases rested with one of the pairs of quadrants of a Kirchhoff electrometer, the other pair being put to earth. The atmospheric moisture condensed on the outside of the vases. The observed deviations of the electrometer were of the same order of magnitude whether the vases were empty or full of ice, being sometimes in one direction, sometimes in the other. The best results were obtained, however, by compressing air into a glass reservoir, connecting the metallic rod passing into its interior with the electrometer. During the expansion the moisture condensed on the rod, but the needle showed no deviation. It cannot, consequently, be affirmed that condensation of aqueous vapor is a source of atmospheric electricity. (*Wied. Ann.*, xx, 614; *J. Phys.*, May, 1884, II, iii, 219.)

It is generally assumed that ordinary zinc is positive to amalgamated zinc in a solution of zinc sulphate. But Robb has shown that if care be taken to employ pure zinc, and solutions of sulphate free from acid, the couple shows no sensible electro-motive force. Lippmann has discussed this result, and shows that the contrary result is in direct contradiction to the second law of thermo-dynamics, since the action of the current developed would cause the deposition of zinc on the pure zinc, which could then be amalgamated again, and so on; a finite quantity of work being done at the expense of the amalgamation only. With cadmium in cadmium sulphate, however, the polarity is reversed, and hence there is no conflict with the above law. (*J. Phys.*, September, 1884, II, iii, 388.)

Carhart has determined the relation between the electro-motive force of a Daniell cell and the strength of the zinc sulphate solution, employing for the purpose the compensation method of Poggendorff. With a 1 per cent. solution the electro-motive force was 1.125 volts; 3 per cent., 1.133; 5 per cent., 1.142; 7½ per cent., 1.120; 10 per cent., 1.118; 15 per cent., 1.115; 20 per cent., 1.111; and 25 per cent., 1.111; the mean of

the whole being 1.122. Testing a Latimer Clark standard cell by this method, the author obtained for its value 1.434 volts. Hence the variation in the strength of the zinc sulphate solution affects the electromotive force. (*Am. J. Sci.*, November, 1884, III, XXVIII, 374.)

Beetz has proposed a simplified form of Daniell cell for use as a normal element, which is of remarkable constancy at different temperatures, and which, owing to its high resistance, falls off only slightly on closed circuit. The battery for charging the quadrants of an electrometer is made by filling glass tubes, 8^{cm} long and 5^{mm} in diameter, one-half full of plaster of Paris mixed with solution of copper sulphate, and the other half with plaster mixed with zinc sulphate solution, wires of copper and of zinc being placed in the corresponding mixture, the external ends being soldered together alternately. Twelve of these form a row, and twelve of these rows form the battery, the difference of potential of the 144 cells being 152 volts. The entire battery occupies a space of only 16^{cm} square. (*Wied. Ann.*, XXII, 402; *Phil. Mag.*, September, 1884, V, XVIII, 173; *Am. J. Sci.*, November, 1884, III, XXVIII, 390.)

Another standard cell devised by Beetz is a modified Latimer Clark cell. It consists of a tube in which a compressed cake of mercurous and zinc sulphates is placed, the zinc being on one side of this cake and the mercury on the other. The electro-motive force was 1.44 volts, which on short circuiting for 48 hours fell only to 1.408. Its resistance is 15.7 ohms. (*Nature*, October, 1884, XXX, 568.)

At the Montreal meeting of the British Association one of the subjects for general discussion was the seat of the electro-motive forces of the voltaic cell. It was opened by O. J. Lodge, who inclined to the chemical theory, in opposition to Sir William Thomson and others, who favored the contact theory. Printed copies of notes prepared by Dr. Lodge, containing the points involved in the question at issue, were distributed before the meeting. (*Nature*, October, 1884, XXX, 594.)

Quite a number of new forms of voltaic cell have been proposed. Reynier has studied the effect of varying the size of the electrodes in a battery upon its electro-motive force, and has constructed two cells which he calls maximum and minimum cells. The former has a copper plate plicated so as to have a surface of 30 square decimeters, or 300 times as large as that of the zinc plate, which is simply a wire 3^{mm} in diameter. The containing vessel has a capacity of 800 c. c. and the cell has a resistance of 0.2 to 4 ohms, according to the liquid used. The latter, while exteriorly of the same size, contains a negative electrode 5 sq. dm. in size, the positive being a copper wire 0.5^{mm} in diameter, the surface immersed being 1 sq. cm. With these batteries he has measured the maximum and minimum electro-motive force of the ordinary electrolytes. In dilute sulphuric acid, the zinc being amalgamated, the maximum electro-motive force observed was 1.072 volts and the minimum 0.272. The maximum cell, charged with a liquid composed of 20 parts salt in 100 of water, he proposes as a standard

cell, its electro-motive force being 0.82 volt between 5° and 40°. (*J. Phys.*, October, 1884, II, III, 444, 448.)

Lalande and Chaperon suggest cupric oxide as the depolarizing agent in the battery. The oxide is placed on the copper plate, which is covered with a solution of caustic potash, and a plate of zinc is suspended in it. The electro-motive force is 0.98 volt and the cell is remarkably constant. (*Nature*, January, 1884, XXIX, 227.)

Tommasi and Radiquet have constructed a battery with two carbon electrodes. The positive plate is placed at the bottom of a porcelain jar and covered with lead peroxide, the negative plate is covered on its surface with platinized coke, the two being separated by a sheet of parchment paper. A solution of common salt is used as the electrolyte, which must not completely cover the upper plate. The electromotive force on closed circuit is 0.6 volt. (*C. R.*, July, 1884, XCIX, 129.)

Pabst has invented an iron cell, the electrodes of which are carbon and wrought-iron in a solution of ferric chloride, and which is claimed to be non-polarizable and self-regenerating. The oxygen of the air is absorbed in the working of the battery, and ferric oxide is deposited at the bottom of the cell. Its electro-motive force is about 0.78 volt. (*Nature*, January, 1885, XXXI, 203.)

Bartoli has designed a battery in which the material consumed is carbon, which is in the form of a compacted mixture of Ceylon graphite and retort coke. This constitutes one of the electrodes, while the other one is platinum. The exciting liquid is sodium hypochlorite, and the electro-motive force is only about 0.2 volt. (*Nature*, January, 1885, XXXI, 203.)

Jablochkoff has produced a battery of considerable scientific interest. A small rod of sodium, weighing about 8 grams, is squeezed into contact with an amalgamated copper wire and flattened. It is then wrapped in tissue paper and fastened by wooden pegs to a plate of very porous carbon. The sodium absorbs the moisture of the air and no solution is required. Its electro-motive force is 2.5 volts, but its resistance is 25 ohms. (*Nature*, January, 1885, XXXI, 203.)

Skrivanow's battery consists of zinc and of silver chloride enclosed in parchment paper and immersed in a solution composed of 75 parts caustic potash in 100 of water. The enclosing vessel is a hard rubber cup which is hermetically sealed, and the whole weighs 100 grams. The electro-motive force is from 1.45 to 1.50, and the cell will give a current of 1 ampere for about an hour. Then the solution must be renewed, and after two or three renewals of this the silver chloride must be replaced. (*C. R.*, January, 1884, XCVIII, 224.)

Gore has constructed a new and convenient form of thermo-electric apparatus for measuring small electro-motive forces by the method of opposition. It consists of about 300 horizontal, slender, parallel wires of iron and German silver, the former covered with cotton. These wires are about 8 inches long, fixed side by side in close mutual con-

tact, though insulated from each other, as a continuous flat layer about 16 inches long, soldered end to end in an alternating series. About 1½ inch in length at each end is bent downward so as to dip into two liquids of different temperatures contained in two long, narrow troughs. The hot one is melted paraffin, kept at 120°; the cold one is a non-volatile petroleum. The resistance of 295 pairs of such wires was 95.6 ohms at 16° C.; and when the difference of temperature in the two baths was 100° the electro-motive force was 0.7729 volt, and when it was 130°, 1.005 volts. Each element gave, therefore, 0.0000262 volt for 1°. With this apparatus measurements have been made to the $\frac{1}{35000}$ part of a volt. The author finds it very useful in practice. (*Nature*, March. 1884, XXIX, 513.)

Von Waltenhofen has observed that the Noe thermo-battery is capable of taking a charge like an accumulator. When the current of a battery is sent for a few moments through one of these generators, it is capable of yielding a counter-current, due, of course, to the well-known Peltier effect. A different effect, however, was observed according to the direction of the charging current. When this current was in one direction, the discharge currents were proportional to these and were always in the opposite direction. But when the charging current was reversed, the discharge current at first increased to a maximum, then decreased to zero, then began in the reverse direction, or that of the charging current. The author ascribes this anomalôus result to the unequal heating of the junctions. (*Nature*, January, 1884, XXIX, 227.)

Two important papers have appeared having for their object the discussion of the theory of the dynamo-electric machine. The first of these is by Clausius (*Wied. Ann.*, XX, 353; *Phil. Mag.*, January, February, 1884, V, XVII, 46, 119; *J. Phys.*, July, 1884, II, III, 313), and the other, on machines with alternating currents, by Lucas (*C. R.*, March, 1884, XCVIII, 670), who used the Meritens machine in his experiments.

Fitzgerald has sought to produce a non-sparking dynamo by applying the principles of Maxwell's modification of Thomson's electric doubler to a dynamo, in which the current passes through two or more coils in parallel circuit. Under these circumstances it is possible to arrange the magnetic field and the brushes so that when the terminals of any coil come into contact with their brushes the terminals shall be at the same difference of potential as the brushes, so that when they break contact there shall be no current circulating in the coil, and therefore no sparks produced. The energy of self-induction, usually wasted on local currents and sparks will now be spent in the production of useful current. (*Nature*, July, 1884, XXX, 331.)

3. *Electrical Units and Measurements.*

The International Electrical Conference held in Paris in April concluded the business before it and adjourned finally. Each section adopted resolutions as follows: First section, electric units: (1) The

legal ohm is the resistance of a column of mercury of a square millimeter in cross-section and 106^{cm} in length, at the temperature of melting ice. (2) The conference expresses the wish that the French Government should transmit this resolution to the different states, and recommend an international adoption of it. (3) The conference recommends the construction of primary standards in mercury conformable to the resolution previously adopted, and the concurrent employment of scales of secondary resistances in solid alloys, which shall be frequently compared amongst one another and with the primary standard. (4) The ampere is the current the absolute value of which is 10 to the power minus 1 in electro-magnetic units. (5) The volt is the electro-motive force which maintains a current of 1 ampere in a conductor the resistance of which is 1 legal ohm. Second section, earth currents and atmospheric electricity: (1) It is to be desired that the results of observations collected by the various administrations be sent each year to the International Bureau of Telegraph Administration, at Berne, which will make a digest of them and communicate it to the various Governments. (2) The conference expresses the wish that observations of earth currents be pursued in all countries. Third section, standard of light: (1) The unit of each kind of simple light is the quantity of light of the same kind emitted in a normal direction by a square centimeter of surface of molten platinum at the temperature of solidification. The practical unit of white light is the quantity of white light emitted normally by the same source. (*Nature*, May, 1884, XXX, 26; *J. Phys.*, June, 1884, II, III, 229.)

Rowland has completed his determination of the length of the mercury column 1 sq. mm. in cross-section which has a resistance of 1 ohm. The experiments were made at Clifton, 2 miles from Baltimore, the expense being defrayed by the Government. The resistance of columns of pure mercury, contained in glass tubes of various calibers and lengths, was first determined in B. A. units, and then the determination in ohms of the B. A. standard completed the measurement. Three methods were used in the latter comparison. The first consisted in heating some non-conducting liquid, such as alcohol or turpentine, by the current, in a conductor whose ends were kept at a known difference of potential, the same heating being then produced mechanically, thus determining the resistance of the conductor in terms of the work-equivalent of the heat. The second method used was that of Kirchhoff, as modified by Rowland in his 1876 determination of the ohm. The third method was the earth-inductor method of Weber. Unfortunately the experiments were not completed in season to have the results communicated to the Paris conference in April, but they were communicated to the American Electrical Conference held in September in Philadelphia. Rowland gives as the length of the mercury column, as the mean of his experiments, 106.27^{cm}. (*Science*, January, 1884, III, 10; *Elec. World*, September, 1884, IV, 101.)

Mascart, De Nerville, and Benoït have made a determination of the length of the mercury column required by the legal ohm, using for this purpose the methods of Kirchhoff and Weber. They conclude as follows: "The experiment appears to us to show that the value of the ohm is surely comprised between 106.2 and 106.4^{cm}; we may consider the value 106.3 as exact, at least to $\frac{1}{1000}$ part." (*C. R.*, April, 1884, XCVIII, 1034; *J. Phys.*, June, 1884, II, III, 230.)

Benoit has constructed for the French Government four mercury standards corresponding to the ohm of the conference. These are straight glass tubes whose caliber is nearly 1^{mm}. The resistances as measured were 1.000017, 0.999996, 0.999960, and 1.000003 ohms, or 0.999994 as a mean. (*C. R.*, XCIX, 864, November, 1884.)

The committee of the British Association has announced that arrangements have been completed for testing resistance coils at the Cavendish Laboratory, and issuing certificates of their value. They assume the B. A. unit to be 0.9867 of a standard ohm. (*Nature*, XXIX, 465, March, 1884.)

Edelmann has modified the quadrant electrometer of Thomson by making the quadrants cylindrical, formed by slitting a metal tube into four parts by four equidistant cuts parallel to the axis. The needle consists of two portions of metal cut from a cylinder, united above and below and hung by a single fiber, directive force being given by a small attached magnetic needle. (*Nature*, January, 1884, XXIX, 239.)

Chervet has described a new form of capillary electrometer with horizontal tube, in which this tube is slightly conical, and which is empirically graduated. With a lens magnifying six times, a difference of potential of 0.00001 Daniell cell may be observed. (*J. Phys.*, June, 1884, II, III, 258.)

Garbe has laid down the two following laws in relation to the capillary electrometer of Lippmann: (1) The capillary constant of mercury is greatest when the electrical difference at the meniscus is nil, and as a rule its value is independent of the sign of this difference. (2) The electrical capacity at a constant surface of an electrode plunged in a liquid is purely a function of the electrical difference, independent of the sign of that difference, and is least when that difference is nil. (*Nature*, October, 1884, XXX, 568.)

Lippmann has contrived a mercury galvanometer based on the action of magnets on currents. A mercury manometer in the form of a U-tube is placed between the poles of a permanent magnet, so that these poles are on the right and left side of the horizontal portion. The current to be measured is made to traverse this horizontal portion in a vertical direction; *i. e.*, perpendicular to the axis of the tube. A difference of level is thereby produced in the manometer columns proportional to the strength of the current. In one of the author's instruments this difference is equal to 23^{mm} for 1 ampere; in another to 58^{mm} for 1 ampere. The apparatus is reversible; by moving the mercury me-

chanically a current is developed. (*C. R.*, May, 1884, XCVIII, 1256; *J. Phys.*, September, 1884, II, III, 384.)

An obvious modification permits this instrument to be converted into an electro-dynamometer. A small retangular chamber filled with mercury is placed at the center of a coil of copper wire. The current to be measured passes successively through the coil of wire and the layer of mercury, which communicates laterally with the two branches of a manometer, and causes a difference of level in the mercury columns which is rigorously proportional to the square of the current strength. It may be graduated in absolute measure; in one of the author's instruments a current of 1 C. G. S. unit, or 10 amperes, produces a pressure of 650 dynes, or about 650 milligrams per square centimeter. It may be used for direct or alternating currents, and when once graduated may serve as a standard. (*C. R.*, June, 1884, XCVIII, 1534; *J. Phys.*, September, 1884, II, III, 387.)

Several new forms of galvanometer have been described. T. and A. Gray have constructed a very sensitive instrument, consisting of two pairs of coils with hollow cores, arranged so that the axes of each pair are parallel and in a vertical plane, and act on a needle system consisting of two horseshoe magnets of thin steel wire, connected by a very light frame of aluminum, and hung with their planes vertical, so that a horseshoe corresponding to each pair of coils has its poles within the hollow cores. Each pair of coils is carried by a vertical brass plate, the two plates being placed so as to make an angle with one another of about 100°. Certain other instruments are described, in which two perfectly vertical and straight needles are used to give an astatic system. (*Nature*, March, 1884, XXIX, 444.)

In D'Arsonval and Deprez's galvanometer the coil is movable and the magnet fixed. A powerful horseshoe magnet placed vertical, with its poles upward, has a rectangular coil suspended between these poles by fine silver wire. A small cylinder of soft iron is supported within the rectangle for the purpose of re-enforcing the magnetic field. A mirror above the rectangle enables the deflections to be read. The instrument is very dead-beat and will indicate a millionth of an ampere. (*Nature*, November, 1884, XXXI, 86.)

Bosanquet has devised what he calls a standard tension galvanometer, which is a form of tangent galvanometer independent of any process of calibration, and whose accuracy depends only on the usual measures of dimensions and the knowledge of the horizontal component of the earth's magnetism, together with its resistance. (*Phil. Mag.*, January, 1884, V, XVII, 27.)

Böttcher's solenoidal galvanometer consists of a soft iron cylinder 1 to $1\frac{1}{2}^{cm}$ in diameter and 20^{cm} long, suspended by a thread to a spring-balance, so that one half projects from a firmly fixed coil of wire. (*Phil. Mag.*, March, 1884, V, XVII, 248.)

Ducretet's instrument has the two astatic needles in the same horizontal plane. (*C. R.*, October, 1884, XCIX, 605.)

Stone has described an electro-dynamometer with an extremely light suspended coil made of aluminum wire. (*Nature*, XXX, 635, October, 1884.)

Bellati has substituted for the needle of a reflection galvanometer a small cylinder of soft iron suspended bifilarly in a direction perpendicular to the magnetic meridian, the vertical coil through which the current passes being inclined 45° to this meridian. Since the electro-magnetic action preserves always the same sign, the instrument acts as an electro-dynamometer. If a bundle of soft iron wires be used, 0.15^{mm} in diameter and 17^{mm} long, the instrument readily indicates telephone currents. (*J. Phys.*, May, 1884, II, III, 220.)

4. *Electric Spark and Electric Light.*

Foster and Pryson have given a simple formula to represent the difference of potential required to give sparks in air. If this difference of potential be represented by V, and the length of the spark in centimeters be l, their experiments give approximately $V = 102l + 7.07$. The results were obtained with brass balls 1.35^{cm} in diameter, a frictional machine, and a Foster absolute electrometer. When $l = 0.142$, the difference of potential was 154.76; with $l = 0.284$, $V = 133.35$; for $l = 0.497$, $V = 131.66$; and for $l = 0.9$, $V = 138.57$; the value of V diminishing then and increasing again. (*Nature*, March, 1884, XXIX, 446.)

In his Bakerian lecture, Schuster has ably discussed the experiments which have made on the electric discharge through gases, and has given a sketch of a theory of this action. He shows that the negative glow is divisible into three layers, increasing in thickness with decreasing density. In the first place, a luminous layer closely surrounds the electrode, which, when this is new, is of a golden color. The spectroscope shows in this the presence of sodium and hydrogen. The second layer is known by the name of the dark space. The third layer is the glow proper. The theory proposed is this: that within the first layer the gaseous molecules are decomposed, that their respective parts are projected with great velocity through the dark space, that this velocity is gradually reduced by impacts within the glow, and that in the positive part of the discharge the discharge takes place by diffusion, except when stratifications appear. (*Nature*, July, 1884, XXX, 230.)

E. Wiedemann has also investigated the phenomena of the electric discharge in gases. He supposes that the positive discharge consisting in a current preceded by a polarization of the gas is an electrical phenomenon proper, and he attributes it to a longitudinal motion. The negative rays are the true luminous rays, of very short wave-length, energetically absorbed by the ponderable medium, in which they excite phosphorescence. The negative electrode is a source of transversal waves, exerting on their front, according to Maxwell, a pressure which

the Crookes phenomena prove. (*Wied. Ann.*, xx, 756; *J. Phys.*, II, III, 210; *Phil. Mag.*, July, August, 1884, V, XVIII, 35, 85.)

De la Rue and Müller have studied the discharge of 15,000 cells of the silver chloride battery, using two very slightly convex disks, a point and disk, and two paraboloidal points, the potential being increased a thousand cells at a time. Inspection of the curve shows that it is continuously concave for the disks, while for the disk and point and two points it is concave only for a certain distance and then turns off and becomes convex. The intensity of force per centimeter decreases continuously up to 15,450 volts in the case of planes; but in the other cases the decrease ceases after a certain potential has been reached, and then increases so as to be nearly a constant quantity. At 9,000 volts, and beyond, the potential between a point and a disk is very nearly 9,200 volts; hence, if the law holds good, to produce a spark 1^{dm} long, 92,000 volts; 1^{m} long, 920,000 volts: and a flash of lightning a kilometer in length, 920,000,000 volts, would be required. This would, of course, be lessened by the diminished atmospheric pressure at that height. Under a mean pressure of 939,211 M it would require 864,-000,000 to produce a discharge between a cloud a kilometer high and the earth. In an induction coil a spark of 1 inch requires 23,367 volts, 1 foot 280,400 volts, and 1 yard 841,230 volts. (*Nature*, January, 1884, XXIX, 327.)

Lucas has determined the resistance of the arc produced in the Serrin lamp, between two Carre carbons 16^{mm} in diameter. With a 50-ampere current, the carbons being separated 4^{mm}, he finds the resistance to be 0.58 ohm. (*C. R.*, April, 1884, XCVIII, 1040.)

Schneebeli has examined the radiation from the Swan incandescent lamp at various temperatures, employing the method of Svanberg and Langley. The resistance of the lamp, cold, was 80 ohms. The current strength, the total radiation of the lamp, and the luminous radiation were measured, and it appeared that for each current strength C there exists the following relation: $C^2R = KW$, in which R is the resistance of the carbon at the designated temperature, W the energy emitted by the lamp, and K a constant. If R is constant between 900° and 1,500°, then $\frac{C^2}{W}$ is constant. The results show that the resistance of carbon between a red and a white heat is apparently independent of temperature. The absorption coefficient of the glass globes of the lamp is also apparently independent of temperature. (*Wied. Ann.*, XXI, 430; *Am. J. Sci.*, September, 1884, III, XXVIII, 225.)

The electric light systems exhibited at the Cincinnati Exposition were tested by a jury consisting of Mendenhall, Eddy, French, and Laidlaw, and their report has been published. The dynamometric measurements were made by means of the Brackett dynamometer, specially constructed. The current strength was measured by one of Thomson's current galvanometers and a Brackett differential galvanometer. The electro-mo-

tive force was measured on Thomson's potential galvanometer, a high-resistance Thomson galvanometer and a condenser being used to check the indications. The photometric power of the lamps, both arc and incandescent, was determined in terms of an Edison 16-candle lamp taken as a standard. The efficiency found for the Thomson-Houston arc dynamo was 81.5; of the Weston arc dynamo, 86.5; of the Weston incandescent dynamo, 87.9; and of the Edison incandescent dynamo, 95.1. In the case of the arc lamps the jury found a difference of more than 40 per cent. in favor of the Thomson-Houston, and in that of incandescent lamps they found a difference of 25 per cent. of light per electrical horse-power in favor of the Edison. (*Science*, February, 1884, III, 174.)

5. *Electro-chemical Decomposition.*

Jahn, in a paper communicated to the Vienna Academy, has shown that in the electrolysis of solutions of copper sulphate and of zinc sulphate between two electrodes of platinum, the quantities of heat which become free during the decomposition of equivalent weights of the two salts are inversely as the quantities of heat evolved during the formation of these salts by means of the two metals, of oxygen and of sulphuric acid. (*J. Phys.*, June, 1884, II, III, 274.)

Warburg has succeeded in electrolyzing glass by heating it to 300° between mercury electrodes. The glass used was a soda-lime glass, which is a conductor at this temperature. The current of 15 to 30 Bunsen cells was used, and at first passed freely; but in a few moments the current diminished, and in the course of an hour fell to $\frac{1}{1000}$, from the formation at the anode of a layer of insulating silica. This siliceous layer acted as the dielectric of a condenser between two conductors; and by charging it with from 5 to 20 Bunsen cells, the condenser was found to have a capacity of from 0.021 to 0.041 microfarad, according to the thickness of the layer. If sodium amalgam be used as the anode, no layer of silica results, but sodium is found in the mercury on the cathode side, the amount of which was found to agree with the weight of silver deposited in a voltameter in the same circuit. Potassium amalgam is without action. (*J. Phys.*, October, 1884, II, III, 452; *Phil. Mag.*, August, 1884, V, XVIII, 159.)

Gore has propounded a theory of the relation of heat to electrolysis which assumes that metals and electrolytes are throughout their masses in a state of molecular vibration; that the molecules of these substances, being frictionless bodies in a frictionless medium, and their motion not being dissipated by conduction or radiation, continue incessantly in motion until some cause arises to prevent them; that each metal or electrolyte when unequally heated has to a certain extent an unlike class of motions in its differently heated parts, and behaves in those parts somewhat like two metals or electrolytes, and those unlike motions are enabled, through the intermediate conducting portion of the substance, to render those parts electro-polar; that every different

metal and electrolyte has a different class of motions, and in consequence of this they also, by contact alone with each other at the same temperature, become electro-polar. The molecular motion of each different substance also increases at a different rate by rise of temperature. (*Nature*, January, 1884, XXIX, 300.)

Hammerl has studied the conditions of accuracy in the copper voltameter, and finds them to be as follows: (1) The liquid should not be heated above 40°, for fear of oxidizing the deposit; (2) the plates should be nearly rectangular, preferably circular, parallel, and varnished on the back; (3) if they are not less than 1.5^{cm} apart, the density of the current for exact measurement should not exceed 7 amperes per square decimeter. (*J. Phys.*, April, 1884, II, III, 178.)

Mascart has repeated his determination of the electro-chemical equivalent of silver, and now finds that a coulomb will deposit 1.1156 milligrams of silver and will decompose 0.09303 milligram of water. The values found by Kohlrausch were 1.1183 and 0.09325, respectively. (*J. Phys.*, July, 1884, II, III, 283.)

Rayleigh has also determined the electro-chemical equivalent of silver and finds $1{,}118 \times 10^{-2}$ for its value in C. G. S. units. One ampere-hour deposits 4.025 grams silver. (*Proc. Roy. Soc.*, March, 1884; *J. Phys.*, July, 1884, II, III, 307.)

Lodge, in a paper on storage batteries, concedes that at the present time it is pretty generally felt that no existing form of storage battery is perfect, and that on the whole such batteries are extravagant and wasteful to an extent sufficient to more than compensate for their undeniable convenience. "It is perfectly certain," he says, "that their employment has not become at all general, and that they have failed to realize the somewhat sanguine hope of their early promoters." Storage batteries would be useful, he thinks, (1) to economize now wasted power, like water-power; (2) to obtain regular from irregular action, as wind and tides; and (3) to obtain strong but short—from long-continued though weak action. (*Nature*, October, 1884, XXX, 585.)

NECROLOGY OF PHYSICISTS, 1884.

GINTL, J. WILHELM, professor emeritus of mathematics and physics at Gratz, a telegraph engineer and inventor of a duplex system of telegraphy. Died at Prague December 22, 1883, aged 80 years.

MERRIFIELD, C. W., principal of the royal school of naval architecture, South Kensington. Died at Brighton, Eng., January 1, 1884, aged 56 years.

DALLMEYER, JOHN HENRY, physicist and optician, celebrated for his photographic lenses. Died in London in January, 1884, aged 53 years.

DU MONCEL, THÉODORE, electrician and physicist, editor of La Lumière Électrique. Died in Paris February, 1884, aged 63 years.

HAGEN, G. H. L., a well known hydraulic engineer. Died in Berlin February 3, 1884, aged 86 years.

TODHUNTER, ISAAC, an eminent professor of mathematics and mathematical physics. Died at Cambridge, Eng., March 1, 1884, aged 64 years.

BOUTIGNY, G. H., a well known physicist and investigator, especially in the domain of heat. Died in Paris March 17, 1884.

DUMAS, J. B. A., the eminent chemist and physicist. Died at Cannes April 11, 1884, aged 84 years.

BONTEMPS, CHARLES, telegraph engineer, director of pneumatic telegraphs in Paris. Died in Paris in May, 1884, aged 45 years.

MOIGNO, F. N. M., mathematician and physicist, editor for many years of the French Journal Les Mondes. Died in Paris July 13, 1884, aged 81 years.

WOODWARD, J. J., a surgeon in the U. S. Army, well known as a microscopist and investigator. Died in Philadelphia August 18, 1884.

SCHELLEN, HEINRICH, director of the Realschule at Cologne, and author of several electrical and scientific works. Died at Cologne in September, 1884, aged 66 years.

SABINE, ROBERT HENRY, a telegraphic engineer, and son-in-law of Sir Charles Wheatstone. Died in London October 25, 1884, aged 47 years.

LARTIGUE, HENRY, a telegraphic engineer of eminence, director of the Paris Telephone Company. Died in Paris in November, 1884, aged 54 years.

VON JOLLY, PHILIP, professor of mathematical and experimental physics in the University of Munich. Died in Munich in December, 1884, aged 74 years.

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CHEMISTRY

By H. CARRINGTON BOLTON,

Professor of Chemistry, Trinity College, Hartford.

GENERAL AND PHYSICAL.

The Color of Chemical Compounds as a Function of the Atomic Weights of their Constituent Elements.—Thomas Carnelly finds that the color of chemical compounds depends on at least three conditions—(1) the temperature, (2) the quantity of the electro-negative element, and (3) the atomic weights of the constituent elements. Of these three conditions the two former have been especially studied by Mr. Ackroyd, whose results are thus summarized:

(1) All the chromium compounds change their color in a definite serial order, that of the spectral colors, in such a manner that as the temperature rises the color approximates more and more to the red end of the spectrum, and ultimately, at a sufficiently high temperature, passes into brown and black. Most frequently the transition of color is direct from white to a pale yellow, while violet, indigo, blue, and green are passed over as transition stages.

(2) In binary compounds an increase of the quantity of the electro-negative element involves a change of color to the red end of the spectrum, and ultimately into brown and black.

(3) Dr. Carnelly expresses his law as follows. Influence of the atomic weight: in some series of compounds, Ax Ry; Bx Ry; Cx Ry; &c., in which R is an element or a group of elements, while A, B, C, &c., signify elements belonging to the same subordinate group in Mendelejeff's table of the natural classification of the elements, the color passes entirely or partially through the following scale: White or colorless, violet, indigo, blue, green, yellow, orange, red, brown, black, with the increasing atomic weight of the elements A, B, C, &c. In other words, the higher the atomic weight of the elements A, B, C, rises, the more the color of the compound approaches the red end of the spectrum, and passes in certain cases into brown and black. This rule applies only when the elements A, B, C, &c., belong to the same sub-group. In 426 cases examined the author found only 14 exceptions, 4 four of which, $DiCl_3$, V_2O_3, CrO_3, and CdO, do not admit of satisfactory

explanation. The author thinks that there are indications that the color of compounds is a periodic function of their atomic weights. This is best seen in the normal iodides. He proposes extending his researches to the colors of organic bodies. (*Berichte d. chem. Ges.*, XVII, 2151.)

The Periodic Law and the Occurrence of the Elements in Nature, by Thomas Carnelly.—The theory concerning the occurrence of the elements in nature is based upon the periodic law, and comprises four points:

(1) Elements which belong to the odd series (of the periodic classification) are as a rule readily brought into the free condition. On the other hand, those elements belonging to the even series are only set free with difficulty. Carbon, nitrogen, oxygen, sodium, magnesium, and silicon are the only exceptions to this rule, which is explained by the inverted character of the "curve of the elements."

(2) Elements belonging to the even series, with the exception of carbon, nitrogen, and oxygen, and the group VIII, never occur in nature in a free state. The elements belonging to the odd series frequently occur in this condition.

(3) The elements belonging to the odd series occur in nature ordinarily as sulphides or double sulphides (selenides, arsenides, &c.), *i. e.*, in combination with a negative element belonging to an odd series, rarely as oxides. Elements belonging to the even series are commonly found as oxides or double oxides (with formation of silicates, carbonates, sulphates, aluminates, &c.), that is to say, in combination with a negative element belonging to an even series, and never (with two exceptions) as sulphides.

(4) The halogens chlorine, bromine, iodine, fluorine, the most electronegative elements, occur in nature in combination with the most electropositive metals, as chlorides, bromides, iodides, and fluorides, and (omitting certain metallic oxychlorides and sulphochlorides) in combination with oxygen or sulphur.

The above-mentioned facts may be thus expressed with reference to Lothar Meyer's curve of the elements: Elements whose place is on falling parts of the curve are difficult to reduce, and never occur in nature in a free condition or in combination as sulphides, but always in combination with oxygen as oxides or double oxides (silicates, sulphates, carbonates, &c.); while the elements whose place is on ascending parts of the curve are easily reduced, and occur almost always—more or less—in a free condition, and also in combination with sulphur and very rarely with oxygen. (*Berichte d. chem. Ges.*, XVII, 2287.)

Explanation of Gladstone and Tribe's 2-3 Law in Chemical Dynamics, by John W. Langley.—Gladstone and Tribe showed that if a plate of metal is suspended in a solution of another metal which it can precipitate, the rate of chemical action, as shown by the loss of weight in the suspended plate (for a given period of immersion), will vary with the

percentage strength of the solution in a remarkable manner, which they epitomize in the following statement: If the percentages of the salt be expressed by a series of the powers of 2, the chemical action will be expressed by the corresponding powers of 3. In their experiments they employed a plate of copper suspended in a solution of silver nitrate. Since the authors offered no explanation of this law, Professor Langley raised the following questions: Is the rate of metallic precipitation for varying strengths of the solution due to the chemical action alone, or is the operation of chemical affinity compounded with one or more purely physical forces; and, if so, what is the relative part contributed by each?

To solve the problem Professor Langley devised apparatus for bringing the solution against the plate with uniform velocity; this was suggested by an observation of Gladstone and Tribe that two currents, one ascending and one descending, formed during the precipitation. Professor Langley arranged a plate of copper so that it revolved 5½ times per second, and as a result of many trials, made in divers ways, he arrived at this law: In metallic precipitations of dilute solutions the chemical action varies directly as the mass, *i. e.*, percentage of the dissolved salt.

Gladstone and Tribe's experimental work was confirmed, and Professor Langley offers the following explanation of their law: When the plate is suspended in the liquid a film of copper nitrate is at once formed against it. Now, the access of fresh silver nitrate depends on the removal of copper nitrate; this film, being heavier than the main solution, begins to fall (a part also rises), and thus drags in fresh liquid from above to attack the copper. The rate at which it falls depends upon its density, that is, on the quantity of copper dissolved, but it is resisted by the inertia of the surrounding fluid which it must displace. Now, as the percentage of silver nitrate in the solution is increased the density of the copper nitrate increases, and it will descend faster. The rate of motion, however, is dependent on several considerations, which the author discusses fully, and he concludes that the observed rate of action will be made up of two factors: twice the chemical action because of chemism, and 1½ because of gravitative action; or, when the percentage of silver salt is doubled, the quantity of copper dissolved will be tripled. This is Gladstone and Tribe's law.

The author thinks it probable that the true law of chemical action, where one metal precipitates another, should be that the time during which one atom replaces another in a compound molecule is constant, and hence that the rate of total chemical action varies directly as the mass of the reacting body in solution. (*Journ. Chem. Soc.*, December, 1884.)

Certain Phenomena attending Mixture, by Prof. F. Guthrie.—Experiments conducted with a number of different liquids show that mixtures can be arranged in two distinct classes. Of the first a mixture of water and ether is an example; when shaken up together they mix, heat

is *evolved*, and a *diminution* of bulk takes place. If any excess of ether present be poured off, and the lower clear liquid heated in a sealed tube, it becomes turbid, owing to the separation of the ether. This is accompanied by an *increase* in bulk and *absorption* of heat.

Alcohol and carbon disulphide form a typical case of the second class of mixtures. These liquids mix with each other, in all proportions above 0° C., with *increase* of bulk and *absorption* of heat. Upon cooling the mixture to about −17° C. the liquids separate. In these cases the action is regarded as a chemical one. (*Chem. News*, L, 233.)

On a Relation between the Molecular Weights of Liquids and their Velocities of Evaporation, by C. Schall.—On distilling successively in the same apparatus given volumes of benzene and of water, the author found that, even when the boiling was maintained as nearly uniform as possible, very different weights of these two substances passed over in the same time. Even in a rough experiment the quantity of benzene in the receiver was double that of the water. With a view to give the experiment greater exactness, the time of evaporation of equal volumes of these liquids was carefully determined. Knowing, then, the density of the liquids at the boiling point, their weights could be calculated, and hence the exact time of evaporation of equal weights.

On comparison the values thus obtained appeared to be very nearly in the inverse ratio of the molecular weights of the liquids employed. Thus, benzene, with a boiling point of 79.2° and a density of 0.8136, evaporated in 12.7, 12.95, and 12.3 minutes; while the same volume of chloroform, boiling point 61.5° and density 1.4048, evaporated in 14.3, 14.5, and 14.3 minutes; or, reduced to equal weights, in 8.25, 8.4, and 8.28 minutes.

Since $m : m' = t' : t$, the first value gives for the molecular weight of chloroform 119.64, the second 120.25, and the third 119.88, the true value being 119.5. Benzene, when compared with carbon disulphide, boiling point 45.3° and density 1.2212, evaporated in 12.3 minutes, while the same volume of CS_2 required 19 minutes; or, reduced to equal weights, 12.66 minutes. This gives, by calculation, a molecular weight of 75.79 in place of 76. Water, boiling point 99° and density 0.9596, evaporated in 64 minutes; or, reduced to equal weights, in 54.26 minutes. This gives a molecular weight of 17.68 instead of 18. Moreover, the ratio of the volumes of two liquids evaporated in equal times is the ratio of their molecular volumes. Thus, the ratio for benzene and chloroform above given is 1.126 : 1; whence 1.126 : 1 = 95.94 (the molecular volume of benzene) : 85.2 (the molecular volume of chloroform). Schiff obtained 84.65. The author has further observed that on comparing Regnault's values of the heat of vaporization of several liquids, these numbers decrease as the molecular weight increases. From which, of fifteen liquids whose heat-data are known, thirteen fall readily into five groups, in each of which the product of the heat of vaporization by the molecular weight is approximately constant. Thus, water gives 536.67 × 18 = 9660.06,

while alcohol gives $214.3 \times 46 = 9857.8$; acetone gives 7523.76, chloroform 7289.5, and carbon tetrachloride 7161; ethyl oxide 6711.8, carbon disulphide 6301.2, and ethyl chloride 6128.7; stannic chloride 11736.4, arsenious chloride 12292.99, and ethyl acetate 12820.72; phosphorous chloride 8970.5 and ethyl iodide 8938.8. The remaining two are amyl alcohol, which gives 17954.64, and bromine, 7963.2. These do not seem to belong to any of the above groups, unless the latter be placed in that containing acetone. (*Am. Journ. Sci.*, CXXVII, 233, in abstract by G. F. B. from *Berichte d. chem. Ges.*)

On the Connection between Pseudo Solution and True Solution, by W. W. J. Nichol.—The well-known Brownian motion of small particles suspended in a liquid being regarded as a consequence of molecular impacts is applied by the author to support the *molecular* as distinguished from the *hydrate* theory of solution. According to the former theory, the solution of a salt in water is a consequence of the superior attraction of the molecules of water for those of the salt as compared with the cohesion of the salt itself. Substances are soluble in inverse proportion to their cohesion. Cohesion being destroyed by subdivision, a finely divided substance remains suspended for a long time in water. Such suspension or *pseudo solution* differs only from true solution in respect to fineness of division of the solid. If subdivision could be carried to the isolation of the molecules, true solution would result, and substances thus dissolved could separate from solution only slowly, in spite of the superior cohesion of their molecules, because aggregations of these molecules sufficiently large to separate themselves from solution could only occasionally be found. As an instance of this we have slow precipitation of many insoluble substances from solution when cold and dilute. (A. A. B., from *Chem. News*, L, 124.)

INORGANIC.

Liquefaction of Hydrogen.—S. Wroblewski has subjected hydrogen to a pressure of 100 atmospheres in a glass tube of 2^{mm} external diameter and of 0.2–0.4^{mm} internal diameter. The tube was placed vertically, and by means of a screw the compressed gas could be released instantaneously. The tube and contents were cooled by boiling oxygen. At the moment of releasing the hydrogen an ebullition appeared in the tube similar to that observed by Cailletet in oxygen, in his experiments made in 1882. The phenomenon is produced in the same manner at a certain distance from the bottom of the tube; it lasts for a much shorter time and is less decided and much less easy to perceive. The reason of this difficulty may perhaps be explained by the very low density of liquid hydrogen. Cailletet and Hautefeuille, in their researches on the density of oxygen, hydrogen, and nitrogen liquefied in the presence of a liquid having no action on these elements, have inferred that liquid hydrogen has a density of 0.033. Since the same method yielded under the same conditions

the number 0.89 for the density of oxygen, Wroblewski admits that the figures 0.033 are not far from the truth. On the other hand, gaseous hydrogen reaches this same density, 0.033, at a low temperature, under inconsiderable pressures; hence arises an optical difficulty in distinguishing the liquid from the gaseous hydrogen, a difficulty which probably prevented Wroblewski from reproducing Cailletet's experiment on hydrogen. The analogy between the phenomenon described and those presented by oxygen permit the supposition that the temperature necessary for the complete liquefaction of hydrogen is not far from that which may be obtained by means of boiling oxygen. (*Comptes rendus*, XCVIII, January 28, 1884.)

Boiling Point of Hydrogen.—Dr. Edmund J. Mills, on purely mathematical considerations, has calculated the boiling point of hydrogen at —215° C. This figure remains to be confirmed by Wroblewski and Olzewski, who are separately engaged in investigating the subject. According to the former, oxygen boils at —184° and nitrogen at —193°, under the ordinary pressure. Olzewski, who uses a hydrogen thermometer, claims to have measured a temperature of —213° C. (*Chem. News*, L, 179.)

Liquefaction of Oxygen by the Aid of Marsh Gas.—Cailletet has discovered that marsh gas (formene) can be used to liquefy oxygen, without employing mechanical means for lowering the temperature of boiling of the cooling liquid. The formene is compressed and cooled in ethylene boiling under atmospheric pressure; in the liquid state it is very mobile, and in vaporizing lowers the temperature sufficiently to immediately liquefy oxygen. This process greatly simplifies the liquefaction of oxygen gas. (*Comptes rendus*, XCIX, 1565.)

Atomic Weight of Carbon determined by Combustion of the Diamond, by C. Friedel.—Having obtained, through the generosity of Mr. Chatrian, a number of very fine white diamonds from Africa, the author made combustions in a current of oxygen, with a view to determining the atomic weight of carbon with unusual accuracy. The experiments gave C=12.007 when O=16. The ashes remaining after the combustion were small white flakes, yellowish in places, with small black spots. Some were attracted by the magnet; several were transparent, and of these some were acted on by polarized light, having preserved their crystalline form. The weight of the ashes was about 0.058 per cent. of the diamond.

During the combustion the diamond did not change into coke, as has been claimed by others, but was merely roughened on the surface, as if attacked by an acid. (*Bull. soc. chim.*, XLI, 100.).

The Atomic weight of Glucinum, by L. F. Nilson and Otto Pettersson.—A few years ago these authors concluded, from their experiments on the specific heat of glucinum, that the atomic weight of this element is 13 65,

and not 9.1, as had been generally admitted. Lothar Meyer attempted to show that their results are capable of a different interpretation, quite in harmony with the atomic weight 9.1. Afterward Nilson replied to Meyer, and, taking into account the specific heats of the oxide and sulphate of glucinum, found confirmation of his view that the atomic weight is equal to 13.65. If this figure be correct, the periodic law receives a serious blow, for with the larger atomic weight glucinum does not fit into the scheme based on the law. In the article under review the authors named give the results of the determination of the specific gravity of gaseous glucinum chloride, and find that the correct formula is $BeCl_2$, in which the atomic weight is equal to 9.1. In view of this result, they add, and of the fact that Avogadro's law is, without exception in the whole field of chemistry, the basis for the conception of the molecule, we must give up the idea formerly held by us that glucinum is a trivalent element, to which we were led by the agreement of the atomic heat ($Be'''=13.65$) with the law of Dulong, and the numerous analogies between the physical constants (molecular heat and volume) of the compounds of glucinum, on the one hand, and of the rare metals scandium, erbium, yttrium, &c., on the other. While recognizing in this important case the validity of the periodic law, we at the same time call special attention to the singular fact that the laws of Dulong and of Avogadro lead to exactly opposite conclusions regarding the atomic weight and value of the element of glucinum, a fact which is unique in the field of metallic elements. (*Ber. d. chem. Ges.*, XVII, 987.)

Redetermination of the Atomic Weight of Cerium, by Henry Robinson.—The author details the precautions taken in preparing the cerous chloride and in conducting the experiments. The mean of seven determinations of the chlorine (made by titration with silver nitrate) gives 139.8584 as the atomic weight of cerium if $H=1$, or 140.2154 if $O=16$. (*Chem. News*, L, 251.)

Redetermination of the Atomic Weight of Platinum, by W. Halberstadt.—As a result of 97 analyses of no less than five different compounds of platinum, conducted in two distinct series, the author finds for the atomic weight of platinum the value 194.57592. (*Berichte d. chem. Ges.*, XVII, 2962.)

Additional determinations of atomic weights.

Element.	Atomic weight found.	Authority.	Reference.
Aluminium	27.0	Baubigny	*Compt. rend.*, XCVII, 1369.
Samarium	150.0	Cleve	*Compt. rend*, XCVII, 94.
Tellurium	125.0	Brauner	*Bull. soc. chim.*, XLI, 320.

Iodide of Nitrogen and its Use in Actinometry, by Antony Guyard.—The author prepares iodide of nitrogen by acting on one gram of iodine with 8 c. c. of aqua ammonia at 22° B. With less ammonia, the ammonium iodide which forms removes some of the iodine from the product. Exposed to direct or diffuse sunlight, the iodide of nitrogen is immediately decomposed, with liberation of nitrogen, and the reaction is so clean as to be useful in actinometry. Explosions result occasionally if the iodide be subjected to the action of light under water, but under ammonia at 22° B. the decomposition ensues quietly, with effervescence. By determining the weight or volume of the nitrogen liberated in a specified time, the reaction may be applied to measurement of the energy of sunlight. The reaction is expressed thus: $2\ NH_2I = NH_4I_2 + N$. Iodide of nitrogen is decomposed rapidly, sometimes with explosions, by dilute sulphuric and hydrochloric acids; it dissolves without danger in sodium hyposulphite and in potassium sulphocyanide, ammonia being set free. (*Bull. soc. chim.* [2], XLI, 12.)

Antiseptic Value of Carbon Disulphide.—In October, Prof. Eug. Péligot presented a paper to the French Academy of Sciences on the utility of an aqueous solution of carbon disulphide in the treatment of the vine attacked by phylloxera. He showed that the liquid is far more soluble in water than the determinations made by Mr. Ckiandi established; at ordinary temperatures water dissolves 3.5 c. c. per liter, or 4.52 grams, its density being 1.293. Its antiseptic properties have also been fully confirmed by the further investigations of Pasteur, who anticipates that it will become the most efficacious of all antiseptics, it being also the cheapest, costing only a few centimes per liter. It is, moreover, the best known insecticide, and has already rendered great services in the destruction of phylloxera. At present 30,000 hectares (about 74,000 acres) of vineyards are yearly treated with over 4,000,000 kilograms of carbon disulphide, with excellent results. When applied in the form of potassium sulphocarbonate, it has a double action, the sulphur derivatives killing the insect and the potash enriching the soil. (*Nature*, XXX, 628.)

Disinfection by Combustion of Carbon Disulphide.—Carbon disulphide forms on burning, carbon dioxide and sulphur dioxide. In consequence of the yield of the latter product, the liquid has been recommended by a French commission as the best material for disinfecting rooms in which patients suffering from contagious diseases had sojourned. The liquid carbon disulphide is more easily burned than sulphur, and is less injurious to furniture or metallic articles in the apartments.

Presence of Carbon in ordinary Phosphorus, by Ira Remsen and E. H. Keiser.—As a contribution to the question regarding the action of moist phosphorus on carbon monoxide, Professors Remsen and Keiser have quantitatively determined the amount of carbon in ordinary phosphorus.

Six analyses gave results varying between .026 and. 043 per cent. carbon. (*Am. Chem. Journ.*, VI, 153.)

Researches on Titanium Compounds, by Otto Freiherr v. d. Pfordten.—Ebelmen obtained TiS_2 by heating together titanium chloride and sulphuretted hydrogen; the author obtains TiS in small crystals by heating the disulphide in a current of hydrogen, carefully excluding oxygen. The former is yellow, the latter black in color. Attempts to reduce TiO_2 in a similar way yielded only the indigo-blue oxide Ti_3O_5 discovered by Deville. The author noticed the formation of gelatinous titanic acid, analogous to the silicium compound, noticed by H. Rose in his investigations. (*Berichte d. chem. Ges.*, XVII, 727.)

Extraction of Cæsium and Rubidium from Hebron Lepidolite, by F. C. Robinson and C. C. Hutchins.—The authors recommend mixing the powdered mineral with an equal weight of fluor-spar and heating the mixture for some hours in a sand-bath with strong sulphuric acid. When cold the mass is broken up, lixiviated and filtered. The filtrate contains the Cs, Rb, and K as alums, which are easily separated by their great differences in solubility at 17°. One thousand grams lepidolite yielded about 30 grams cæsium and rubidium alums. (*Am. Chem. Journ.*, VI, 74.)

Electrolytic Magnesium.—Adolph Grätzel, of Hannover, Prussia, has devised a method of preparing pure magnesium on a large scale by the electrolysis of carnallite. This mineral, which abounds in the upper part of the salt formation at Stassfurt, consists essentially of the chlorides of magnesium and potassium with water, and contains from 31 to 36 per cent. of $MgCl_2$. At the session of the German Chemical Society in Berlin held March 10, 1884, Dr. Grätzel exhibited a bar of magnesium weighing one-half kilogram and of great purity. The absence of sodium is especially noted, a metal present in all commercial magnesium hitherto made. The electrolytic magnesium does not decompose water at ordinary temperatures. If the new process will furnish magnesium in abundance at a low price, the importance of this discovery will be very great. (*Berichte d. chem. Ges.*)

Magnesium Hydrosulphide Solution as a Source of Hydrogen Sulphide, by E. Divers and Tetsukichi Shimidzu.—The authors wishing to obtain a regular stream of pure hydrogen sulphide found that this could be effected by gently heating a solution of magnesium hydrosulphide. Ordinary hydrogen sulphide (from ferrous sulphide and hydrochloric acid) is passed into water containing magnesia in suspension. The gas is absorbed and the magnesia dissolves. On heating the colorless solution to 60°–65° it gives out a steady current of hydrogen sulphide, free from hydrogen and from hydrogen arsenide. The magnesia which is precipitated during the evolution of the gas may be again used in the preparation of the magnesium hydrosulphide. (*Chem. News*, L, 233.)

Compounds of Chromium Sesquichloride with metallic Chlorides, by Abbé Godefroy.—The author finds that the sesquichloride of chromium forms with chlorides of several metals well defined and crystallized combinations. The method of preparation is as follows: To obtain a compound of chromium chloride with the chloride of a metal, R, pass a current of chlorine gas into a mixture of 700 grams of alcohol and 300 grams of the chromate (or dichromate) of R, until the liquid fumes freely when exposed to the air. If the liquid separates into two layers, add enough alcohol and continue to pass the chlorine. Decant, filter through glass wool with the aid of a filter-pump, wash with concentrated HCl, and dry on a plate of porcelain at a gentle heat. Transfer to dry and well-corked bottles. These double salts are decomposed by water with the formation of HCl. Bromides and iodides of chromium and the metals are obtained in a similar manner. The potassium salt has the formula $4\ KCl \cdot Cr_2Cl_6 + 2\ H_2O$. (*Bull. soc. chim.*, XLII, 194.)

Recovery of Zinc from the Residues of Pyrites.—At the Wocklum Works a process has been in operation for many years by which zinc chloride is recovered from the burnt pyrites. The burnt ore is lixiviated, thus extracting the iron and cupric sulphates; the lixivium is concentrated to crystallization, is mixed with a quantity of sodium chloride equivalent to the zinc sulphate in the solution, and thereby deposits Glauber's salts, the value of which alone covers the whole expense of treatment. The mother liquid is concentrated; various mixed ferrous and sodium sulphates crystallize out; the zinc chloride remaining in solution is obtained by evaporating to dryness. The dry salt contains, however, about 15 per cent. sodium salts. (*Revue scientifique Quesneville.*)

On the Bromides of Tin, by Bohuslaw Rayman, and Karl Preis.—The authors describe the dibromide and tetrabromides of tin, and several compounds of the latter with other metallic bromides. $SnBr_2$ forms a crystalline, yellowish, transparent mass, melting at 215.5° to a pale yellow liquid. It forms with water a crystalline hydrate, which appears in colorless needles or thin prismatic crystals, soluble in water with turbidity. $SnBr_4$ distills at 196° to 198°, and the distillate solidifies to a mass of crystals with a white, mother-of-pearl luster. They rapidly deliquesce on exposure to the air, and form a hydrate, $SnBr_4 \cdot 4\ H_2O$. The following compounds are also described: Stannohydrobromic acid and its salts of sodium ($Na_2SnBr_6 + 6\ H_2O$), of calcium, strontium, magnesium, manganese, iron ($FeSnBr_6 + 6\ H_2O$), nickel, and cobalt; also the oxybromide of tin ($Sn_3Br_6O + 12\ H_2O$). (*Liebig's Annalen*, CCXXIII, 323.)

Permeability of Silver by Oxygen Gas, by L. Troost.—The author shows that pure oxygen and the oxygen of the atmosphere are capable of passing through the sides of a heated tube of silver, while only a trace of nitrogen permeates the metal. Carbon monoxide and dioxide also penetrate the silver, though less rapidly than oxygen. The author

suggests that pure oxygen may be manufactured from air on this principle. The silver must not be heated above 800° C. (*Comptes rendus*, XCVIII, June 9, 1884.)

On Bismuthic Acid, by Carl Hoffmann.—The highest oxide of bismuth, bismuthic acid, has the formula Bi_2O_5. The potassium salt is obtained by passing chlorine into a solution of potassium hydroxide (specific gravity 1.539) in which bismuth hydroxide is suspended. The operation is repeated three times, with the addition of fresh lye. The potassium bismuthate so obtained is of the composition 2 $BiO_3K + nBi_2O_5$. It is of a red-brown or dark violet-brown color, and contains more or less potassium according to the strength of the lye. By treating the body repeatedly with water holding carbon dioxide in solution, a lighter-brown compound is formed, not quite free from potassium. These compounds treated with acetic acid leave an orange-colored bismuthyl-bismuthate, Bi_4O_9, and treated with dilute nitric acid, a yellow-brown body, Bi_4O_8. (*Liebig's Annalen der Chemie*, CCXXIII, 110.)

The Alkali Industry, by Walter Weldon.—In our review of the progress of chemistry in 1883 we gave an abstract of Mr. Weldon's paper before the London section of the Society of Chemical Industry, January 8. This eminent authority on the alkali industry delivered (July 9, 1884) an address as retiring president of this society, in which he continues to trace the decline of the Leblanc method and the increasing growth of the ammonia method. The ammonia process being more than 70 per cent. cheaper than the Leblanc process per given quantity of soda, the only claim the latter has for continuance is in its production of the necessary article hydrochloric acid. In order to avoid closing Leblanc soda works, the makers have temporarily combined to reduce production and force up prices.

One of the important problems connected with the ammonia-soda industry is the recovery of the chlorine at present thrown away in the calcium chloride. Mond has recently patented the following process: The residual liquor, consisting of a nearly saturated solution of sodium and ammonium chlorides, is evaporated to such a degree that the sodium chloride deposits, leaving the ammonium chloride in solution; this is then evaporated to dryness and the solid salt treated with enough sulphuric acid to convert it into hydroammonium sulphate, the chlorine going off as HCl. The residual sulphate is then treated with free ammonia, and so converted into neutral ammonium sulphate, for sale as such, or it is sold to manufacturers of ammoniacal phosphatic fertilizers. This process is, after all, not the recovery of chlorine from the calcium chloride, but from the sodium chloride, and it involves, moreover, a radical change in the process, viz, the abandonment of the plan of regenerating the ammonia employed, and the necessity of finding a sale for the ammonium sulphate produced. Mr. Mond is said to manu-

facture 50,000 tons of ammonia-soda annually; and if the above process were applied to the whole of the product, he would not only produce 128,000 tons of ammonium sulphate, but he would be obliged to consume one-third more ammonia than the total quantity at present produced in all Great Britain and Ireland. Obviously the process cannot be extensively applied so long as we depend on the distillation of coal for ammonia.

A combination of the first step in the Leblanc process, and the substitution of sodium sulphate for the chloride in the subsequent treatment by the ammonia process, has been found theoretically possible, but its commercial merits remain to be proven. The natural objection to this modification is that the first step of the Leblanc process is the costly one.

Messrs. Carey, Gaskell, and Hurter have devised a more practicable process, based upon the decomposition of sodium sulphate by bicarbonate of ammonia, and the recovery of both the ammonia and the sulphuric acid. These chemists find that if a mixture of equivalent quantities of ammonium sulphate and sodium sulphate be heated to fusion, and steam be injected into the liquid mass, the whole of the ammonia is set free, and the sulphuric acid combines with the sodium salt, forming hydro-sodium sulphate, which alone remains behind. This hydro-sodium sulphate can then be used to decompose sodium chloride. The normal sodium sulphate resulting is decomposed by bicarbonate of ammonia, with production of bicarbonate of soda and ammonium sulphate, which last can be used to repeat the first step. These processes have the advantage of no waste, a merit not shared by the Leblanc process, invented ninety-seven years ago by the immortal Nicholas. (*Chem. News*, L, 41.)

Use of Nickel Vessels for Operations with fixed Alkalies, by Professor Dittmar.—Fleitmann, in 1879, suspecting that the brittleness of nickel was due to the presence of occluded carbonic oxide, had the happy thought of fusing the metal with a small proportion (one-eighth part) of magnesium, and obtained thereby a regulus capable of being rolled into thin sheets and drawn into fine wires. Since this important discovery the inventor has made a business of manufacturing kitchen utensils which are nickel inside and outside, with a core of iron between. Basins of this make are found by Professor Dittmar very useful in operations with caustic alkali solutions, and they are far cheaper than silver. These nickelized vessels cannot be used with fused potassium or sodium hydroxides, since the latter attack strongly every metal save gold. (*Chem. News*, L, 3.)

Constituents of Snow-Water, by Dr. Elwyn Waller.—A sample of snow was carefully collected in a stoppered bottle after snow had been falling for three or four hours and the ground was well covered. After

the large particles of sand, coal, &c., from neighboring locomotives had settled out, the water was analyzed, with the following results:

	Parts per 100,000.
Chlorine	Trace
Phosphates	None
Nitrates	None
Nitrogen in nitrates	0.0494
Free ammonia	0.0396
Albuminoid ammonia	0.0318
Hardness	0.91
Total solids	6.3

While the water was settling, a slimy fungoid growth collected on the bottom and sides of the vessel. The presence of volcanic ash (presumably from Krakatoa) was not established. (*Chem. News*, L, 49.)

Occurrence of Manganese in Plants and Animals, by E. Maumené.—Wheat, rye, rice, and barley are shown to contain manganese, probably combined with an organic acid. The bran and starch of wheat do not contain the element. It is also found in potatoes, beets, carrots, lentils, peas, parsley, and in exceedingly minute quantities in apples and grapes. It is found in a large proportion in cocoa, still larger in coffee, and most of all in tea. It is absent in oranges, lemons, onions, &c. Human blood does not always contain it; very small traces occur in milk, urine, bones, and hair. It is almost entirely eliminated in the solid excrements, and should be regarded as non-essential to life; hence manganese must not be substituted for iron in medicine. (*Comptes rendus*, XCVIII, June 9, 1884.)

Notes on Explosives.—Panclastite, the new explosive invented by Eugene Turpin, consists essentially of a mixture of liquid nitrogen tetroxide with carbon disulphide in the proportions of $3\ N_2O_4 + 2\ CS_2$. The mixture is exploded by a fulminate primer, with a result more powerful than that of nitro-glycerine. If ignited without confinement in a vessel it burns with a brilliant flame, which M. Turpin proposes to utilize as a signal in the field or for photographic purposes. The heat of combustion is also very great, being estimated at about 3,000° C.; platinum fuses instantly under the action of this flame. The advantages claimed for this explosive are greater power than dynamite, perfect safety of the separate constituents in transport and storage, insensitiveness of the mixture to blows, and easy control of the manufacture by the Government, owing to the fact that nitrogen tetroxide is not met with in commerce.

Explosive gelatine, or gelatine dynamite, is made by dissolving photographic gun-cotton in nitro-glycerine, or by mixing nitro-glycerine with collodion, removing the solvent by evaporation. The solution is aided by heat, and yields a gelatinous mass of a consistency varying with the

amount of the soluble gun-cotton. The jelly is very insensitive to blows, and is not easily exploded, requiring a very powerful fuse. and is not injured by water. It is said to be 75 per cent. stronger than dynamite, and it is very free from liability to accident or injury in use or transportation. On the other hand, its stability is questioned. General Abbot found that samples underwent spontaneous decomposition, separating into cellulose and free nitro-glycerine, with a copious evolution of nitrous fumes.

Sir Frederick Abel, chief of the chemical bureau of the Woolwich Arsenal, had a miraculous escape from death early in March, 1884. He was barely ninety feet from the place where 1,000 kilograms of gun-cotton accidentally exploded with terrific violence; he was knocked down by the concussion and injured in several places by flying missiles, but in no wise dangerously. Sir Frederick ascribes his wonderful escape to the fact that a strong wind was blowing at the time from him towards the scene of the explosion. (*Munroe's Notes on the Literature of Explosives*, No. VI.)

Toughening Gold and Silver in the Crucible.—Dr. James C. Booth, of the United States mint, Philadelphia, describes a general method of refining gold in the crucible as practiced in the mint. Some brittle gold, having been accidentally melted with a quantity of well-refined and tough gold, was found to have rendered the whole mass very brittle, with a highly crystalline fracture, and therefore useless for coinage. To avoid loss of time and greater cost of refining by acid, it was toughened wholly by fluxing. This was accomplished on 75,162.55 ounces (5,154 pounds avoirdupois) in one and a half days, at a trifling cost, and with scarcely apparent loss. The 75,000 ounces were divided into fourteen melts of about 5,400 ounces each, and each melt was separately toughened. The ingots, easily broken into pieces by striking them on the edge of a wooden box, were put into the crucible with soda ash and anhydrous fused borax, in the ratio of 1 or 2 ounces to a melt, until the crucible was nearly full. It then appeared as a quiet mass of metal covered with a rather viscid slag, disposed to swell and puff. A few crystals of saltpeter, say 1 or 2 ounces, were then dropped successively into the center of the metallic surface, and, as they melted, their spreading out over the whole surface was aided by the concentric motion of the bottom of a small crucible. The moment the visible oxidizing action began to slacken the melter skimmed off by a small black-lead dipping crucible the fluxed matter, as rapidly as was consistent with the care necessary to avoid taking up metal. The remainder in the melting-pot was the toughened metal. The points to be noted are (1) that one part of foreign matter sufficed to impart brittleness to 75,000 parts of good standard gold; (2) by a slight oxidizing process the matter causing brittleness was removed with no appreciable loss of gold; (3) moreover, the ratio of copper remained constant after the fluxing; (4) the tough-

ening proceeds from the top downward to the depth of 9 to 12 inches of its own accord. (*Chem. News*, L, 37.)

Determination of Nitrogen by Combustion with Calcium Hydroxide.—Prof. S. W. Johnson showed in 1873 (*Am. Chemist*, III, 161) that the mixture of sodium hydroxide and calcium hydroxide proposed by Will and Varrentrapp as a reagent for converting organic nitrogen into ammonia, for the purpose of analysis, may be advantageously replaced by a mixture of sodium carbonate and calcium hydroxide. In the Annual Report of the Connecticut Agricultural Experiment Station for 1883, the same chemist gives a series of analyses made with calcium hydroxide alone, and the results warrant this further simplification of the Will and Varrentrapp method for most substances ordinarily encountered in technical work. A tube 14 inches long is recommended for the combustion of 0.5 grams of substances containing 8 per cent. of nitrogen or less. Cochineal solution is preferred as an indicator, being not seriously affected by carbonic acid, quite sensitive in its reaction, and keeping better than litmus. (*Am. Chem. Journ.*, VI, 60.)

Occurrence of Zinc in Drinking-Water.—Mr. C. W. Heaton reports finding 6.41 grains per gallon of zinc carbonate in a drinking-water carried from a spring through half a mile of galvanized iron pipe. The spring water itself was very pure, containing no ammonia, only nitrogen as a nitrate; this, however, was wholly converted into ammonia by the zinc. (*Chem. News*, XLIX, 85.)

Prof. F. P. Venable, of the University of North Carolina, also calls attention to this impurity. The water from a spring 200 yards distant was brought by galvanized iron pipes to a dwelling house, and there stored in a zinc-lined tank, which was painted with white lead. The water became somewhat turbid and metallic-tasting, and its use for drinking purposes was discontinued. Analyses were made after the pipes had been in use about one year. A somewhat full analysis of the spring water was made by Mr. J. C. Roberts. The analyses of water from the tank and directly from the pipe are carried out only so far as zinc, iron, and tests for lead were concerned. The results are calculated in grains per gallon of 231 cubic inches:

Analysis of spring.

	Grains.
Silica	2.45
Lime	.23
Magnesia	.17
Alkalies	.43
Chlorine	.35
Sulphuric acid	.19
Carbon dioxide (calculated)	.45
Total residue on evaporation	4.34

The tank contained 4.48 grains of zinc carbonate per gallon, with a trace of iron and no lead. Water from the pipe gave 4.29 grains of zinc carbonate per gallon and a trace of iron.

It is evident, then, when the dangerous nature of zinc as a poison is taken into consideration, that the use of zinc-coated vessels in connection with water or any food-liquid should be avoided.

Ammonium Fluoride as a Blowpipe Reagent, by Prof. N. W. Lord.—The author recommends ammonium fluoride as a substitute for hydro-potassium sulphate and fluor-spar in developing flame colorations. It has the advantages of being free from fixed alkali and of being easily applied. For testing feldspar or similar silicates a little of the powdered mineral is mixed with ammonium fluoride, placed on a piece of platinum, and moistened with sulphuric acid; the mixture is gently warmed, taken upon a loop of platinum wire, and tested in the flame of a Bunsen burner or of the blowpipe. The alkali flame is nearly as well shown as with the pure salts. A slight change in treatment renders the reagent very useful in detecting boron. A high heat must be avoided. The delicacy of the reaction is surprising. (*Engineering and Mining Journal.*)

The Reversion of Phosphoric Acid has been further investigated by Thomas S. Gladding. In a previous paper he showed that commercial superphosphates contain the reverted phosphoric acid in three forms—combined with lime, with iron, and with alumina. The artificially prepared phosphate of lime (whether dicalcic or tricalcic form) is, under given conditions, wholly soluble in a neutral solution of citrate of ammonia at the temperature of 40° C., while the iron and alumina phosphates treated in the same way become largely insoluble. The citrate of ammonia solution dissolves every form of reverted phosphate at a temperature of 65° (150° F.), and hence should be used at this temperature. These points are fully sustained in the present publication by additional experiments, and the investigation is extended to a consideration of the reversion of soluble phosphates in artificial and natural soils.

The author recommends the following method of analysis of superphosphates, based on the principles stated:

(*a*) *Preparation of Sample.*—Pass the sample through a twelve-mesh sieve. If too wet, a portion must be air-dried and then sifted, and an allowance made by calculation for loss of moisture.

(*b*) *Determination of Moisture.*—Dry 5 or 10 grams at 100° C.

(*c*) *Determination of Total Phosphoric Acid.*—Weigh 2 grams, brush into a 200 c. c. flask, add 50 c. c. nitric acid, together with several c. c. HCl when working with difficulty soluble iron and alumina phosphates. Boil gently for fifteen minutes, cool, fill to mark, mix, filter through a dry filter-paper into a dry receiver, take 50 c. c. of filtrate, place in a beaker, add 25 c. c. concentrated ammonia, then nitric acid to acidity. To the hot liquid add molybdic solution, let stand for one hour at about

65° C., filter, wash with nitrate of ammonia solution, dissolve on paper with hot ammonia solution, and wash with same. Run in magnesia mixture from a burette at the rate of one drop a second, stirring constantly. Let stand several hours, filter, wash with ammonia solution, dry, ignite to whiteness, and weigh.

(*d*) *Determination of Soluble Phosphoric Acid.*—Weigh 2 grams, rub up in a mortar with a soft, rubber-tipped pestle (grinding is avoided), digest in 25 c. c. of cold water, decant clear liquid into a filter-paper, filtering into a 200 c. c. flask, add 25 c. c. of water to residue, digest for several minutes, and again decant. Repeat five or six times, and finally bring all upon the filter-paper and wash till flask is filled to the mark. Mix, take 50 c. c., and estimate P_2O_5 as in (*c*).

(*e*) *Determination of Insoluble Phosphoric Acid.*—Wash the residue upon the paper into a 200 c. c. flask with 100 c. c. citrate solution, cork the flask, digest in a water-bath at constant temperature 65° C. (150° F.) for thirty minutes, with frequent agitation. Filter the warm solution quickly (by the aid of a filter-pump if convenient) and wash with *cold* water. Return paper and contents to the same 200 c. c. flask, add 50 c. c. nitric acid, boil for 15 minutes, and estimate the P_2O_5 as in (*c*).

(*f*) *Determination of Reverted Phosphoric Acid.*—The soluble + insoluble phosphoric acid subtracted from the total will give the reverted phosphoric acid.

Memoranda.—The molybdic solution is made, as usual, to contain 5 per cent. MoO_3, and 60 c. c. are used to every 0.100 gram P_2O_5. The magnesia mixture is made up as follows: 110 grams cryst. $MgCl_2$, 300 grams NH_4Cl, 400 c. c. conc. ammonia, 1,500 c. c. water; 10 c. c. are used to every 0.100 gram P_2O_5. The citrate solution is made of specific gravity 1.09, carefully neutralized. The ammonia solution contains 1 part strongest ammonia to 3 parts of water. The nitrate of ammonia solution is a 10 per cent. solution, slightly acidified with nitric acid. (*Am. Chem. Journ.*, VI, 1.)

ORGANIC.

Nomenclature of Organic Compounds.—As the prodigious number of organic bodies rapidly augments, the difficulty of providing for them a satisfactory system of terminology likewise increases. Prof. Adolf Baeyer proposes certain changes and some novelties; he favors the use of the letter B to express the benzene-ring, and of the letters Py to indicate the pyridine-ring, employing them as in the following example:

B-1, 4-dichloro-Py-1, 3-dioxychinoline.

He also proposes to use the Greek letter ω to denote the first carbon atom in case of the derivatives, this to be followed by α, β, γ, &c., as usual. To distinguish substitutions in the rings from those in the side chains the author proposes to employ the syllable *eso* in the first in-

stance and *exo* in the second. Thus, we might have esotrichlor-exodichlor-ethylbenzene, a name self-explanatory.

Prof. H. Kolbe subsequently attacked these proposed innovations in a severe and sarcastic manner. (*Berichte d. chem. Ges.*, XVII, 960.)

Production of Hydroxylamine from Nitric Acid, by Edward Divers.—In investigating the reducing action of various metals upon nitric acid the author finds that the action of tin, zinc, cadmium, magnesium, and aluminium gives rise to the production of hydroxylamine, especially in the presence of hydrochloric or sulphuric acids. The function of the second acid is to decompose the nitrate as fast as it is produced, and so (1) to hold the hydroxylamine in a more stable state, (2) to preserve it from the destructive action of nitrous acid by preventing the formation of this acid from the reaction of the metal on the nitrate, and (3) to determine the reduction of the nitric acid to hydroxylamine by supplying the hydrogen for reproducing it. The author divides metals into two classes, according to their action on nitric acid. In the first class are silver, copper, mercury, and bismuth; these metals form nitrite, nitrate, and water, and exert no further action, producing neither ammonia nor hydroxylamine. They decompose the nitric acid into hydroxyl and nitroxyl, combining with these radicals to form hydrate and nitrite, which by secondary reactions become water, nitrous acid, and metal nitrate. They therefore separate nitrogen from oxygen (hydroxyl) in decomposing nitric acid, and not hydrogen from oxygen.

In the second class are tin, zinc, cadmium, magnesium, aluminium, lead, iron, and the alkali metals; these form ammonia and generally hydroxylamine, but do not produce nitrous acid or nitrite with free nitric acid. On the other hand, they readily form nitrite by acting on their own nitrate. Two actions are noted: First, upon seven molecules of acid separating as hydroxylamine, the hydrogen of six of them forming nitrate and leaving the seventh converted to water and the said hydroxylamine; Second, they combine with hydroxylamine to form metal-ammonium hydrate, which decomposes with water into metal-hydrate and ammonia. The author considers that nitrites have a constitution indicated by the name "nitronates," the metal being directly united to their nitrogen. The radical is the same as that existing in nitrates—NO_2—these being its metal-oxyl compounds. (*Am. J. Sci.*, CXXVII, 234, abstract from *Journ. Chem. Soc.*, XLIII, 443.)

Action of Nitrous Anhydride on Glycerine, by Orme Masson.—At the ordinary temperature glycerine absorbs nitrous anhydride rapidly, loses its viscidity, and turns yellow; the temperature soon rises and nitric oxide is evolved, with decomposition of the product. If, however, the glycerine is well cooled and the nitrous anhydride is dried over calcium chloride, the decomposition is arrested. As the gas is absorbed, the

volume of the liquid increases greatly ($2\frac{1}{2}$ times) and the yellow color passes to brown, and at the end of the reaction to a dark green. The products form two layers; one is aqueous and contains nitrous acid and the oxidation products of glycerine; the other, which is three times greater in volume, contains chiefly a nitrous ether of glycerine. To isolate the latter the two layers are separated, and the larger portion is distilled on a water-bath in a strong current of hydrogen. The distillate is the trinitrous ether of glycerine, $C_3H_5(NO_2)_3$, mixed probably with the dinitrous compound.

This new body is a yellow, mobile liquid, volatile at ordinary temperatures, distilling at 150°, and decomposing in part with liberation of reddish vapors. Its density at 10° is 1.291. It burns with a white flame and does not detonate when struck. It has a strong nitrous odor. It is soluble in ether, in chloroform, and in benzine, and insoluble in carbon disulphide. It dissolves in acetic acid, with a green color and liberation of NO; it is rapidly reduced by H_2S; it is decomposed by K_2CO_3, forming KNO_3. This ether is insoluble in water, but the latter liberates NO at the point of contact, especially when warmed or agitated. Exposed to the air in presence of moisture the body forms crystals of oxalic acid. It cannot be preserved in sealed tubes, for it spontaneously decomposes with evolution of gas in such quantities as to break them. (*Journ. Chem. Soc.*, XLIII, 341.)

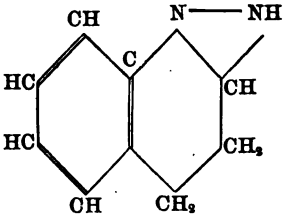
Synthesis of a Coloring Matter similar to that of Litmus, by M. C. Traub and C. Hock.—By the action of small quantities of sodium nitrite on resorcine at 150° a deep-blue material is obtained, which is reddened by an acid in the same manner as a litmus solution.

The best method of preparing the new body is as follows: 100 parts of resorcine, 5 of sodium nitrite, and 5 of water are heated in a flask over an oil-bath gradually to 110°. The yellow mass becomes darker and a lively reaction sets in, necessitating moderation of heat; the contents of the flask becomes raspberry-red and the action is quieter; then the heat is increased to 115°, or 120° at the highest, ammonia being disengaged and the material becoming blue.

The deep-blue solution is diluted and a quantity of hydrochloric acid is added, forming a precipitate, which is collected on a filter and dried. As thus obtained it forms a shining, red-brown, amorphous body, insoluble in chloroform, benzene, and benzine, and soluble in methyl-, ethyl- and amyl-alcohol, in ether, and pure water. All these solutions show a peculiar red color, which is turned to blue by the slightest trace of an alkali. The alkaline solution shows a broad band in its spectrum near the line D, which shades off toward E. In acid solution it cuts off the more refrangible parts of the spectrum.

The exact nature of this substance is under investigation. (*Berichte d. chem Ges.* XVII, 2615.)

Antipyrine, by Ludwig. Knorr.—In the course of the author's researches on derivatives of chinizine, a hypothetical base having the constitution—



he discovered a body having notable antipyretic properities. This substance he calls antipyrine, and it is, in fact, dimethyloxychinizine. It is very soluble and can be used hypodermically. (*Berichte d. chem. Ges.*, XVII, 2032.)

Perseite, a new Sugar, by A. Muntz and V. Marcano.—The fruit of *Laurus persea* contains a sugar closely resembling mannite, and to which the authors give the name perseite. Its formula is $C_6H_{14}O_6$. It crystallizes in small needles, melting at 183°.5 to 184°, and is very soluble in warm water and in alcohol. It is without action on alkaline copper solutions, is optically inactive, and cannot be fermented by the aid of yeast. The ripe nuts of *Laurus persea* contain 6 to 8 per cent. of the sugar. (*Comptes rendus*, XCIX, 38.)

Synthesis of Umbelliferone and of Daphnetine, by H. von Pechmann.—In 1866 Zwenger and Sommer discovered in the bark of the spurge laurel, and in the products of the dry distillation of the resins of umbelliferous plants, a neutral body, to which they gave the name umbelliferone. Later researches showed it to be paraoxycumarine—

$$OH \,.\, C_6H_3 \begin{cases} O \,.\, CO \\ CH = CH \end{cases}$$

The author has made this synthetically by the action of resorcine on malic acid.

By the action of pyrogallol on malic acid the author obtained daphnetine, a derivative of daphnine, a glucoside occurring in the spurge laurel (*Daphne mezereum*). This synthesis proves it to be dioxycumarine; its identity with the natural product was fully established. Daphnine is isomeric with æsculine, and further researches by the author are in progress with a view to its synthesis. (*Berichte d. chem. Ges.*, XVII, 929.)

On the Physiology of the Carbohydrates in the Animal System, by F. W Pavy.—This investigation was undertaken with the object of ascertaining the changes undergone by the four chief carbohydrate elements of food, viz, grape-sugar, cane sugar, lactine, and starch, during digestion. Beginning with the stomach, the attempt is made to follow the

changes in these substances as they proceed towards absorption, up to their arrival within the portal system of vessels. The experiments were performed upon the digestive organs of freshly-killed rabbits, portions of the stomach or intestines being left in contact, for a given time, with solutions of known weights of the carbohydrate in question, and the copper-reducing value of the substance, after this digestion, was compared with that which it had been found to have before contact with the animal substance. Inasmuch as grape-sugar is characterized by the property of possessing the same reducing power after treating with sulphuric acid as before, while the carbohydrates which represent steps in an operation of which glucose is the final product are altered in reducing power by the action of the acid, the author took the precaution to boil one portion of the modified liquid with sulphuric acid in all cases before estimating the reducing power. The copper-reducing value of the digested liquid may thus be compared with that of glucose, while the relation of the modified product to glucose is also ascertained. The most striking result of these experiments is the indication that transformation of glucose into bodies of lower reducing power is possible under the influence of a ferment existing in the stomach and intestines. Boiling of the animal substance with water previous to the experiment was found to annul the action of this ferment. The latter body seems to exist rather within the walls of the vessels examined than upon the mucous surface. So far as the experiments have gone, the author regards them as indicating that this ferment is more abundant in the stomach and intestines of the rabbit than in those of the dog, cat, horse, sheep, or pig. (A. A. B., from *Chem. News*, XLIX, 140.)

Kanarine, a new Dyestuff, by W. Markownikow.—The preparation of this dyestuff, discovered in 1883 by O. Miller, is as follows:

Dissolve one part of sulphocyanide of potassium in two parts of water, and add about one-fifth of the total amount (one-half part) of potassium chlorate and one part of hydrochloric acid. The reaction begins in a few minutes, with evolution of gas and the formation of a yellow precipitate; the vessel is placed in cold water, and the rest of the potassium chlorate and another part of hydrochloric acid is added to the mixture. The temperature should not fall below 80°. An orange-colored precipitate results, which is crude kanarine; this is then purified by solution in warm caustic-potash solution and precipitation with alcohol.

Dried at 100° pure kanarine forms a red-brown powder, with an almost metallic luster. It is insoluble in water, alcohol, ether, and benzene, but easily dissolves in alkaline solutions. Kanarine is destined to become an important dye-stuff, since it can be fixed on vegetable fibers without a mordant. It possesses great tinctorial power and is a fast color. (*Journ. d. Russ. phys.-chem. Ges.*, 1884 (1), 380.)

On the Fractional Distillation of American Petroleum, by D. Mendelejeff.—In the fractional distillation of petroleum from Baku the author

noted an abnormal feature, viz, the rise in temperature from 55° to 62°, 80° to 90°, and 105° to 110° was accompanied by a decrease in the specific gravity of the portions distilling at the temperatures named. A carefully conducted fractional distillation of petroleum of American origin showed that this has the same peculiarity. The petroleum was distilled in an apparatus arranged so that the result was equivalent to 50 simple distillations. At 60° very little distilled over, the specific gravity was 0.6642 at 17° C. and rose to 0.7347 at 80° C., products being collected separately every 2° of rise. The first decrease in specific gravity occurred at 92°, the distillate showing at 75° a specific gravity of 0.7069. A regular increase in the specific gravity followed up to 104°, at which point the specific gravity was 0.7543; then a decrease was noted, the distillate at 115° to 117° having the specific gravity 0.7270. From 117° to 125° the specific gravity increased regularly.

The author ascribes the failure of others to notice this peculiarity to the lack of delicacy in the distillations previously conducted. (*Protok. d. Russ. phys.-chem. Ges.*, 1884, 458.)

Composition of Chlorophyll.—Dr. Adolph Hansen has published important investigations on the nature of chlorophyll. Chemists will remember that Frémy claimed that green chlorophyll consisted of a blue and a yellow constituent. He mixed an ethereal chlorophyll solution with hydrochloric acid, when two layers formed, a lower blue layer and an upper yellow ethereal layer; the blue coloring matter was named by Frémy phyllocyanin and the yellow phylloxanthin. Hansen shows, however, that this is not due to a splitting up of the chlorophyll green into a blue and a yellow component, but only an incomplete separation of the chlorophyll green from the chlorophyll yellow, the former becoming changed to blue by the hydrochloric acid. He further shows that an ethereal solution of pure chlorophyll green treated with hydrochloric acid does not furnish any yellow constituent, the ethereal layer remaining colorless.

It will be remembered that Kraus also supposed he had decomposed chlorophyll green into a blue-green and a yellow component; he called the blue-green cyanophyll, the yellow body xanthophyll. Hansen shows, however, that Kraus is wrong, and his supposed decomposition is only an incomplete separation, and that his cyanophyll is nothing more than an ordinary chlorophyll solution from which a part of the yellow coloring matter has been removed. Both Frémy and Kraus were correct in assuming the existence of yellow and of green bodies, but mistaken in supposing they existed in combination. Hansen shows that they exist side by side, and that chlorophyll is a *mixture* of these coloring matters.

In preparing pure chlorophyll Hansen used the leaves of young wheat-plants. These are first boiled to remove extractives, the water is decanted, and the material washed; it is quickly dried at a low temperature, and then extracted with alcohol of 96 per cent., in a dark room,

to prevent decomposition of the chlorophyll by light. The extraction with alcohol was repeated and the united solutions were concentrated and saponified. This saponification was carried out thus: The alcoholic extract was treated with a moderate quantity of caustic-soda solution (1 part NaHO to 5 H_2O) at a boiling temperature. The alcohol is evaporated by degrees, water is added, and the soap separated by the aid of sodium chloride, the soap precipitating in granular form. It is then shaken in a separating funnel with petroleum ether, which assumes a dark-yellow color, since it removes only the yellow constituent. On evaporating the ethereal solution the *yellow* constituent remains; it crystallizes in dark-yellow needles and gives all the chemical and spectrum reactions of a lipochrome.

The soap is next treated with ether, which removes various impurities, and then with a mixture of alcohol and ether, which removes the *green* constituent; and this, after purification, crystallizes in "sphærocrystals" of great beauty. From 450 grams dried wheat-leaves Hansen obtained 3 to 4 grams solid coloring matter.

In the solid state chlorophyll green is opaque and does not fluoresce; in solution it possesses a red fluorescence.

Chlorophyll yellow occurs in small proportion as compared with chlorophyll green (1:100). Its solutions show no fluorescence. It possesses the reactions of Krukenberg's lipochromes, viz, a blue coloration with sulphuric acid, the same with nitric acid, and a green-blue with a mixture of iodine in potassium iodide. It shows three bands in the blue half of the spectrum, but no absorption of red.

Chlorophyll green has four bands in the red half of the spectrum, agreeing with the four bands of the ordinary chlorophyll solutions. (C. A. Mac Munn, in *Nature*, xxx, 224; condensed from Hansen's *Der Chlorophyllfarbstoff*, *Abeiten des botan. Instituts zu Würzburg*, Vol. III, Heft I, and *Sitzungsberichte der physik-medecin. Gesellschaft*, *Würzburg*, 1883.)

Composition and Methods of Analysis of Human Milk, by Dr. Albert R. Leeds.—In this comprehensive memoir the author gives results of the examination of eighty samples of human milk. After a careful study of many methods of analysis, he greatly prefers that devised by Ritthausen and modified by Gerber, the main points of which are as follows: (1) The *total solids* are determined by evaporating 5 grams in a platinum capsule, after coagulating with absolute alcohol. (2) *Ash:* The residue is ignited gently and then to a dull-red heat. (3) The *albuminoids* are precipitated by sulphate of copper solution, with the addition of sufficient potassium hydroxide solution to exactly neutralize the excess of the sulphate. (4) The precipitate is separated by filtration, with due precautions, and treated with ether to extract fat; the residue, dried at 110° (less the weight of ash), gives the amount of albuminoids. (5) The filtrate from the albuminoids, with washings, is used for the determination of milk-sugar by Fehling's solution. Results are very satisfactory.

Results of analyses of eighty samples of woman's milk.

Constituents, &c.	Reaction uniformly alkaline.		
	Average.	Minimum.	Maximum.
Specific gravity	1.0313	1.0260	1.0353
Albuminoids	1.995	0.85	4.86
Sugar	6.936	5.40	7.92
Fat	4.131	2.11	6.89
Solids not fat	9.137	6.57	12.09
Ash	0.201	0.13	0.37
Total solids	13.267	10.91	16.66
Water	86.732	83.21	89.08

With the exception of the ash, these figures agree very closely with those of König, deduced from the analysis of 190 samples by a great variety of methods. König's mean for albuminoids is 1.95, Leeds's 1.995; 2 per cent., therefore, may be regarded as the average amount of albuminoids in woman's milk.

The author considers also the relations between the physical history of the milk and its composition, especially the (1) color, taste, consistency, and specific gravity; (2) age of the mother; (3) period of lactation and interval since nursing; (4) nationality; (5) physical constitution of the mother.

Unlike cow's milk, the appearance is no indication of the quality of the fluid. Bluish samples often contain most fat, while thin samples often give most total solid matter. A fatty acid of a greenish color was extracted from human milk, which the author thinks is particularly characteristic, and unlike anything obtained from cow's milk. Unfortunately the entire mass of fats was lost by accident in the early stages of manipulation. The characteristic point was the emerald-green color of the ethereal extract of the copper albuminate obtained from numerous samples.

The results of analysis are presented in a graphic chart, which exhibits in a striking manner the great variability in the constitution of woman's milk. (Read before the College of Physicians of Philadelphia, May 7, 1884, and published in *Chem. News*, L, 263 *et seq.*)

Continuous Etherification as applied to other Alcohols than Ethylic, by L. H. Norton and C. F. Prescott.—The authors worked upon mixtures of various alcohols with sulphuric acid and studied the conditions necessary to produce the best results. Beginning with ethyl alcohol, they found that by dropping the alcohol into mixtures of sulphuric acid and alcohol, with boiling-points ranging from 120° to 150° C., they obtained from 7.35 to 28.87 per cent. of the theoretical yield of ether. The best temperature to obtain the maximum yield of ether was found to be from 140° to 145° C., higher temperatures giving no greater yield, while lower

ones gave less. At 160° C. the formation of ether stops, sulphurous acid is evolved, and decomposition takes place. The same results are obtained with propyl alcohol. With isobutyl alcohol decomposition takes place at 120° to 135° C. In the case of isoamyl alcohol the decomposition occurs at 100° C. By mixing the alcohols the authors obtained mixed ethers by the same treatment as with single alcohols. By mixing methyl and ethyl alcohols in molecular proportions, they obtained methyl-ethyl ether in large quantity, together with methyl ether and ethyl ether. Applied to ethyl and propyl alcohols, the corresponding ethyl-propyl ether was obtained. But a mixture of ethylic and isobutylic alcohols did not give ethyl-isobutyl ether, and methyl-isoamyl ether was not obtained from the corresponding alcohols. The conclusions of the authors are that the method of continuous etherification is only applicable in the case of simple ethers, and does not work with those containing more than three atoms of carbon. (*Am. Assoc. Adv. Science, Philadelphia meeting.*)

Liquid Paraffin a Reagent for detecting Water in Alcohol, Ether, and Chloroform, by Léon Crismer.—The new German Pharmacopœia treats of a little-known substance called "liquid paraffin." It forms an oily liquid, consisting of a mixture of hydrocarbons of the methane series, boiling, under 6^{mm} pressure, between 215° and 240° C.

This substance mixes in all proportions with chloroform and ether when they are deprived of water by means of sodium, and forms clear solutions; but the slighest trace of water, or of alcohol containing water, renders the liquid turbid; hence the liquid paraffin forms a delicate test for water in alcohol. Direct experiments show that by it $\frac{1}{500}$ volume of water can be detected in alcohol. It forms a useful reagent for recognizing absolute alcohol. Liquid paraffin readily dissolves chlorine, bromine, and iodine, and colorless phosphorus to a less degree. The author uses the substance in question in the preparation of hydrobromic and hydroiodic acids, as well as of iodide of ethyl. The fact that it is not volatile is of great advantage. (*Berichte d. chem. Ges.*, XVII, 649.)

Glucose.—In response to a request made by the Commissioner of Internal Revenue of the United States, a committee of the National Academy of Sciences, consisting of Profs. George F. Barker, William H. Brewer, Wolcott Gibbs, Charles F. Chandler, and Ira Remsen, has published an exhaustive report on glucose. The letter of the Commissioner called for information "as to the composition, nature, and properties of the article commercially known as 'glucose' or 'grape-sugar'; its saccharine quality as compared with cane-sugar or molasses; and also especially as to its deleterious effect when used as an article of food or drink, or as a constituent element of such articles." Accordingly the report gives details concerning the history, manufacture, and use of starch-sugar, with statistics showing the magnitude of the industry; it also describes the nature of the commercial products, and narrates

the results of new experiments to determine whether the use of glucose is injurious to health.

There are twenty-nine factories of starch-sugar in the United States, using, as nearly as can be estimated, 43,000 bushels of corn per day, yielding products of the annual value of nearly $10,000,000. In Germany the industry is an old one; in 1881–'82 there were thirty-nine factories, consuming over 70,000 tons of starch and producing about 40,000 tons of starch-sugar.

The products are of various grades, appearing in commerce under the following names: (A) Liquid varieties: Glucose, mixing-glucose, mixing-sirup, corn-sirup, jelly-glucose, confectioners' crystal glucose. (B) The solid varieties: Solid grape-sugar, clipped grape-sugar, granulated grape-sugar, powdered grape-sugar, confectioners' grape-sugar, brewers' grape-sugar. The process of manufacture consists, first, in extracting the starch from the corn in a state of sufficient purity, then transforming this into sugar by treatment with dilute acid, and subsequently neutralizing the acid, purifying, and concentrating the product. The steps in the extraction of starch are steeping, grinding, mechanical separation, cleansing, collecting, and washing. A bushel of corn weighing 56 pounds yields, on the average, 30 pounds of starch, 14 pounds of cattle food, and 12 pounds of waste. The transformation of the starch into sugar, termed conversion, is effected in either open or closed converters; the former are wooden vats of 3,000 to 4,000 gallons capacity, the latter are copper vessels furnished with safety-valves and capable of withstanding a pressure of six atmospheres. The acid used is usually sulphuric, and the quantity employed varies with the object of the manufacturer, the liquid product requiring less acid than the solid; the proportion varies from one-half pound oil of vitriol to 1¼ pounds per 100 pounds of starch. In the open converter the starch and acid liquid are boiled until the iodine test ceases to give a blue color, which usually requires about four hours. In the closed converter less time is required, since the pressure is raised to 45 to 75 pounds per square inch.

The sulphuric acid is then neutralized with marble-dust, and the sulphate of calcium removed by filtering through bags of cotton cloth or filter-presses. The liquor is next passed through bone-black filters, concentrated in vacuum-pans, and further purified. The liquid and solid varieties receive different treatment in the final stage.

Both glucose and grape-sugar find extensive application for a great variety of purposes as substitutes for cane-sugar or for barley. The most general purposes for which starch-sugar is used are (1) for the manufacture of table sirup; (2) as a substitute for barley-malt in brewing ale or beer; (3) as a substitute for cane-sugar in confectionery; (4) for the adulteration of cane-sugar, to which it is added to the extent of 20 per cent. or more; (5) for the manufacture of artificial honey; (6) in the manufacture of vinegar; (7) in the manufacture of liquor-coloring, and in many minor applications, such as in cooking, in preparation of

chewing-tobacco, in the manufacture of printers' rollers, and of some kinds of ink.

The following table shows the composition of fair samples of the solid product:

Constituents.	No. 7.	No. 12.	No. 13.	No. 15.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Dextrose	72.7	72.0	73.4	72.1
Maltose	1.8	3.6	1.3	......
Dextrine	4.2	6.4	9.1	9.1
Water	15.1	17.5	14.0	16.6
Total	93.8	99.5	97.8	97.8

The liquid products contain from 34.3 to 42.8 per cent. of dextrose and 29.8 to 45.3 per cent. of dextrine.

The inorganic constituents consist of ash, sulphuric acid, chlorine, ferric oxide, lime, magnesia, and alkalies. No traces of tin, copper, or other metallic impurities were found. The total ash was only between 0.325 to 1.060 per cent.

The question as to the effects of glucose on the health was carefully investigated by Dr. J. R. Duggan, of the Johns Hopkins University. Earlier experiments, chiefly in Germany, were unfavorable to the use of glucose made from potato-starch. Dr. Duggan's experiments occupied two months, during which time he repeatedly took large quantities of concentrated extracts from fermentation (in doses from 120 grams to 160 grams), without the slightest observable effect.

In conclusion the committee thus summarize the results of their investigations: (1) The manufacture of sugar from starch is a long-established industry, scientifically valuable, and commercially important; (2) the processes which it employs at the present time are unobjectionable in their character and leave the product uncontaminated; (3) the starch-sugar thus made and sent into commerce is of exceptionable purity and uniformity of composition, and contains no injurious substances; (4) although starch-sugar has only about two-thirds the sweetening power of cane-sugar, yet starch-sugar is in no way inferior to cane-sugar in healthfulness.

Appendixes to the report give lists of the starch-sugar factories of the United States, the results of examination of commercial sugars with reference to their adulteration with starch-sugar, and a very full bibliography of starch-sugar, prepared by the late Dr. E. J. Hallock. A list of patents relating to the manufacture of starch and starch-sugar completes this valuable report. (*Report on Glucose, prepared by the National Academy of Sciences. United States Internal Revenue, Washington,* 1884. 108 pp. 8vo.

Gallisin, an unfermentable Substance in Starch-Sugar, by C. Schmitt and A. Cobenzl.—With a view to ascertaining whether popular estimation of starch-sugar as an exceedingly unwholesome dietetic article is correct, the authors made a careful investigation into the more obscure ingredients contained therein, and especially of the unfermentable substances. They succeeded in isolating a definite body, which they name gallisin. The process for its extraction and purification is a follows: Five kilograms of commercial starch-sugar were allowed to ferment in a 20 per cent. solution, at a temperature of 28° to 20° C. After five or six days the fermentation was completed. After filtering, the nearly colorless liquid was concentrated as much as possible on a water bath, and the still warm sirup introduced into a large flask. The sirup was then shaken with a large excess of absolute alcohol, when it became viscous, but did not mix with the alcohol. The latter was decanted and the sirup repeatedly agitated with fresh quantites of alcohol, which finally left behind a pulverulent yellow-gray mass. This was then vigorously rubbed in a large mortar with a mixture of alcohol and ether in equal parts, whereby the whole mass was changed into a gray powder. These operations must be conducted as rapidly as possible, to prevent absorption of moisture and deliquescence of the mass. The resulting material is dried under a strong vacuum-pump, washed with alcohol and ether, and dried under a bell-jar, over concentrated sulphuric acid; calcium chloride will not suffice, for the body is more hygroscopic than the calcium chloride itself. This material is further purified by dissolving in water, boiling with animal charcoal, and evaporation to a sirup, which is then poured in a thin stream into a mixture of anhydrous alcohol and ether.

Gallisin so prepared forms a fine white powder, which under the microscope proves to be completely amorphous. As stated, it is far more hygroscopic than calcium chloride. Treated with dilute mineral acids or with oxalic acid it yields dextrose. It does not ferment with fresh yeast. It is slightly sweet to the taste. Analyses lead to the formula $C_{12}H_{24}O_{10}$. Treated in an aqueous solution with an alcohol solution of barium hydroxide, it yields a flocculent precipitate of gallisin-barium, $C_{12}H_{22}BaO_{10} \cdot 3\,H_2O$. Heated to 130° to 140°, under pressure, with three times its weight of acetic anhydride, it dissolved, and subsequent treatment yielded a product which appeared to be hexacetylgallisin. The presence of gallisin in doctored wine was directly proved; at the same time by experiments on lower animals and on human beings it was found to be quite innocuous. (*Berichte d. chem. Ges.*, XVII, 1000.)

Sulphon-Phthaleins, by Ira Remsen.—The analogy in constitution between phthalic and orthosulphobenzoic acids suggested to the author that sulpho compounds analogous to the phthaleins might be obtained by the action of the latter acid upon phenols. Preliminary experiments confirm these views, and the author proposes to make an exhaustive study of the new class of bodies. (*Am. Chem. Journ.*, VI, 180.)

A new Synthesis of Saligenin, by William H. Greene.—Since by the reaction of chloroform or of carbon tetrachloride on an alkaline solution of sodium phenate, salicylic aldehyde may be obtained, the author expected to synthesize saligenin, an oxybenzylic alcohol, by the action of methylen chloride on the sodium phenate. Experiments confirmed his views, though the yield of saligenin was small. (*Chem. News*, L, 76.)

Action of Metals on Chloral Hydrate, by S. Cotton.—An aqueous solution of chloral hydrate is decomposed by most metals, with formation of a metallic chloride. The degree of decomposition depends upon the temperature, the nature of the metal, and the state of fineness of the metal used.

Zinc decomposes chloral hydrate slowly at the ordinary temperatures, but at 80° to 100° the action goes on rapidly, disengaging in one hour 125 c. c. of gas when operating with 600 grams of metal and 10 of chloral. This gas is a mixture of hydrogen with formene and traces of chlorine products. At the same time chloride and oxychloride of zinc are formed, the latter covering the metal and stopping the action. The operation is impeded rather than quickened by amalgamating the zinc. If zinc dust be used, the reaction begins vigorously at the ordinary temperature. Iron acts very differently unless finely divided, in which case it gives the same results as the zinc. (*Bull. soc. chim.*, XLII, 622.)

New Forms of Albumose.—Profs. W. Kühne and R. H. Chittenden in a previous paper described hemialbumose, a cleavage product of the albumins. In studying its reactions the authors noted differences of solubility and inconstancy in the reactions with sodium chloride, circumstances which have led them to the separation of four different forms of albumose, viz: I, protalbumose; II, deuteroalbumose; III, heteroalbumose; and, IV, dysalbumose. These bodies were obtained in part by digestion of fibrin with pepsin-hydrochloric acid, or from the commercial "pepton" manufactured by Witte, and in part from preserved hemialbumose from the urine of a patient with osteomalachia. For details of preparation and properties we refer to the original articles. (*Am. Chem. Journ.*, VI, 31 and 101.)

Investigations on Sinapine and Sinapic Acid, by Ira Remsen and R. D. Coale.—In 1825 Henry and Garot discovered a new substance in white mustard seed to which they gave the name sulphosinapic acid. In 1852 von Babo and Hirschbrunn published an elaborate investigation of this substance, since which practically nothing has been added to our knowledge of the subject. Professors Remsen and Coale have undertaken a new investigation of sinapine and its decomposition products. From 100 pounds of unground white mustard seed they obtained 80 grams pure sulphocyanate of sinapine, which crystallizes from water in beautiful feathery masses. It melts at 176°. The sinapic acid is best prepared from this product by treating it with barium hydroxide. This

acid crystallizes from hot alcohol in small, transparent prisms of a yellowish hue. Carefully purified material was repeatedly analyzed, and the authors came to the conclusion that the composition is represented by the empirical formula $C_{11}H_{12}O_5$. Further researches showed the acid to be monobasic and led to the conclusion that it is butylene-gallic acid, as shown in the formula—

$$C_6H_2\left\{\begin{array}{l} \begin{array}{l}O\\O\end{array}\!\!>C_4H_8 \\ OH \\ CO_2H \end{array}\right.$$

(*Am. Chem. Journ.*, VI, 50.)

Conversion of Organic Isocyanates into Mustard Oils, by Arthur Michael and George M. Palmer.—The action of phenylisocyanate on phosphorus pentasulphide yielded a liquid, boiling between 222° and 223°, having all the properties of phenyl mustard oil. The yield is almost theoretical. The same oil was also obtained by the action of the sulphide on phenyl-urethane. The authors believe the process is capable of generalization, and that the oils may be advantageously prepared. Ethyl mustard oil was obtained by an analogous process. Sulphur estimations made in the products gave results close to the theoretical amounts, and their behavior with aniline further established their identity. (*Am. Chem. Journ.*, VI, 257.)

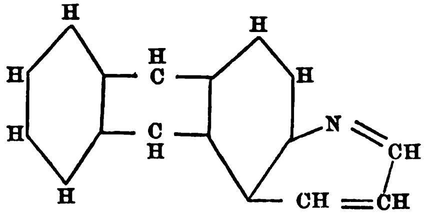
On Fluobenzene and Fluotoluene, by Paterno and Oliveri.—Schmitt and Gehren described fluobenzene as a solid body, melting at 40° and boiling at 180° to 183°. Knowing that the chlorides, bromides, and iodides of benzene are liquid and boil at 132°, 155°, and 185°, respectively, the authors questioned the accuracy of the experiments of the German chemists, and repeated them. They found to their surprise that the fluobenzene of Schmitt and Gehren is nothing but phenol.

Paterno and Oliveri succeeded in obtaining a true fluobenzene by heating in a sealed tube fluobenzene-sulphonic acid, derived from paradiazophenylsulphurous acid and concentrated hydrofluoric acid. Fluobenzene forms a limpid liquid, with the odor of benzene, boiling at 85° to 86°, and not solidifying at 20°. The analogous fluotoluene obtained by the authors boils at 114° and has a characteristic odor of bitter-almond oil. (*Gazz. chim. italiana*, XIII, 533.)

Occurrence of Phenol in Pinus sylvestris.—Dr. A. B. Griffiths announces the discovery of phenol existing in a free state in the stem, acicular leaves, and cones of *Pinus sylvestris*. The phenol was simply extracted by heating with water to 80° C., stirring, and filtering. The filtrate yielded six-sided prisms of phenol hydrate, which were carefully identified. The quantity varies with the age of the stem, the older portions yielding 0.1021 per cent. and the younger portions only 0.0654 per cent. The leaves yielded from 0.0936 to 0.0315 per cent. and the cones from 0.0774 to 0.0293 per cent., according to their maturity.

The author discusses the important bearing of this discovery on the theory that petroleum is produced by moderate heat on vegetable matter. (*Chem. News*, XLIX, 95.)

Synthesis of Anthrachinoline, by C. Graebe.—By heating a mixture of anthramine with nitrobenzol, glycerine, and sulphuric acid the author obtained an anthrachinoline, having a melting point of 17° and identical with that from alizarine blue. This synthesis confirms the author's views concerning the constitution of anthrachinoline, which is shown in the formula:



(*Berichte d. chem. Ges.*, XVII, 170.)

Synthesis of Piperidine, by A. Ladenburg and C. F. Roth.—By the action of sodium in alcoholic solution on pyridine the authors obtained a base having all the properties of piperidine. Piperidine was first obtained by Wertheim and Rochleder from the piperine discovered by Oersted (1819) in long and black pepper. Its formula is C_5H_{10} . HN. Pyridine (C_5H_5N) was discovered by Anderson in bone-oil, and afterwards established as a constituent of coal naphtha. The indentity of the artificial product with that of pepper was fully established. (*Berichte d. chem. Ges.*, XVII, 514.)

Fluid Hydrocarbons obtained by Compression of Petroleum Gas, by Greville Williams.—When the gaseous hydrocarbons obtained by subjecting petroleum to a high temperature are compressed into cylinders (for the purpose of lighting railway cars), a volatile fluid is condensed containing benzene, toluene, and certain olefines. Seven specimens of the liquid gave percentages of benzene and toluene from 65.6 to 24.6. (*Chem. News*, XLIX, 197.)

Anthracene in the Tar of Water-Gas.—Dr. Arthur H. Elliott has established the presence of anthracene in the tar of water-gas. That so heavy a hydrocarbon should result from the destructive distillation of light petroleum naphtha is interesting and instructive. Details will be found in *Am. Chem., Journ.* VI, 248.

Absorption Spectra of the Alkaloids, by Prof. W. N. Hartley.—Experiments have been made to ascertain whether absolute physical measurements can be substituted for the uncertain chemical reactions and variable physiological tests employed to detect alkaloids in medico-legal

examinations. About forty alkaloids of authentic origin and great purity have been examined; these may be divided into two groups, as follows:

(1) *Alkaloids and derivatives exhibiting Absorption-bands in their Spectra.*—Aconitine, pseudoaconitine, japaconitine, morphine, narcotine, codeine, thebaine, papaverine, oxynarcotine, apomorphine hydrochloride, cotarnine hydrobromide, tetracetyl morphine, diacetyl codeine, quinine, quinine sulphate, cinchonine sulphate, quinidine sulphate, cinchonidine sulphate, veratrine, piperine, brucine, strychnine.

(2) *Alkaloids yielding continuous Spectra.*—Narceine, aconitine (foreign), cevadine, atropine, solanine, hyoscyamine, digitaline, picrotoxine, nicotine, caffeine.

Solutions were carefully made of the same strength in most cases, usually in alcohol. Cells, with quartz sides, varied in thickness from 1^{mm} to 20^{mm}. By using electrodes consisting of alloys of tin and cadmium or of lead and cadmium (20 per cent.), well-defined spectra are obtained, with lines of the same intensity, numerous and evenly distributed throughout a spectrum extending from wave length 4414.5 to 2145.8. The spectra were photographed and the photographic impressions were measured by an ivory scale divided in hundredths of an inch. The absorption curves cannot be here reproduced. The conclusions drawn from the investigation are in part as follows: The absorption spectra offer a ready and valuable means of ascertaining the purity of preparations of the alkaloids, and practically of establishing their identity. The quantity of some of the alkaloids present in a solution may be estimated by means of the absorption curves. The different character of the various aconitines, so called, may be recognized; thus, the comparatively harmless base may be distinguished from those of great physiological activity by its transmission of a continuous spectrum, while the three specimens of physiologically active aconitines are distinguished from one another by characteristic absorption curves. The purity of quinine and absence of any admixture of cinchonine can be readily determined; drugs of such potency as aconitine, morphine, strychnine, &c., which ought to be prescribed only when of absolute purity, should have their exact nature and degree of purity guaranteed by an examination of their absorption spectra. (*Chem. News*, L, 287.)

Cocaine Hydrochloride, a new Anæsthetic.—The wonderful anæsthetic properties of this substance, discovered by Dr. Koller, of Vienna, have given it an interest entirely new.

The leaves of *Erythroxylon coca*, a plant cultivated in the mountainous districts of Peru and Bolivia, have been extensively used by the natives as a substitute for tobacco, their practice being to chew the leaves to secure power of enduring fatigue even with a scanty supply of food. The plant, especially the leaves, contains an alkaloid which was first extracted in 1853 by Gardeke and named by him erythroxyline;

but Albert Niemann, of Goslar, subsequently made a more thorough study of the leaves and extracted the alkaloid, which he called cocaine. Niemann's process was as follows:

The leaves were exhausted with alcohol (85 per cent.), to which was added 2 per cent. of sulphuric acid, and to the resulting tincture milk of lime in sufficient quantity. The mixture was filtered, the filtrate neutralized with sulphuric acid, and the alcohol distilled off. The resin was separated from the sirupy residue by treating with water, and sodium carbonate then added. The deposited matter was then exhausted by ether, and the ethereal solution, after most of the ether had been distilled, was allowed to evaporate. The crystals were obtained mixed with a dark-yellowish matter having a disagreeable odor from which, however, they can be separated by washing with cold dilute alcohol.

Purified by recrystallization, cocaine forms colorless transparent prisms, inodorous, of a bitterish taste, soluble in 704 parts of cold water, more soluble in alcohol, and freely so in ether. The solution has an alkaline reaction and a bitterish taste, leaving a peculiar numbness on the tongue, followed by a sensation of cold. The alkaloid melts at 97°.7 C. (208° F.), and on cooling congeals into a transparent mass, which gradually becomes crystalline. Heated above this point it changes color and is decomposed. It is inflammable, boiling with a bright flame and leaving charcoal. With acids it forms crystallizable salts, which are more bitter than the alkaloid itself. The composition of this alkaloid, as determined by Losson, is $C_{17}H_{21}NO_4$.

Its combination with hydrochloric acid, commonly called the hydrochlorate, crystallizes in white, slender needles, easily soluble in water. As stated in Watts' Dictionary of Chemistry, Vol. I, p. 1060 (1866), "it has a bitter taste and produces on the tongue temporary insensibility." This interesting observation, after eighteen years, has borne abundant fruit. Dr. Koller, of Vienna, again noticed its power of benumbing sensation during the course of some experiments on lower animals; a 5 per cent. solution of the hydrochloride of cocaine dropped into the animal's eye entirely deprived the eye of sensation. Koller at once proceeded to experiment on himself and in the hospital, with astonishing results. He communicated his discovery to the International Ophthalmological Congress held at Heidelberg in September, and his results were speedily confirmed by a host of experimenters.

Its chief use is in connection with operations on the eye. A few drops of a 4 per cent. solution are introduced into the eye, and if necessary repeated after a minute or two, until the organ loses entirely its sensitiveness. The loss of sensation begins in three to five minutes and continues from fifteen minutes to half an hour, the effect being superficial. The insensibility is not absolute. The patient feels the operation as he would feel anything laid on his hand or arm, but the sense of pain is almost wholly destroyed. Usually there is a slight feeling, which is said by the patient to be not worth mentioning.

It is unnecessary to repeat that the effect is confined to the part to which the anæsthetic has been applied. There is no general anæsthesia and no influence on the mind. The patient is left free to aid the operation by turning the eye in any required direction, holding down the lid, or in any such way, and can give this help almost as indifferently as a third person, and often more successfully. The absence of the tendency to close the eye, which accompanies general anæsthesia, is a great advantage.

Before the close of the year an immense demand arose for the new drug, and, owing to its rarity and the small supply on hand, its price rose to $225 per ounce, or, according to another report, $7,000 per pound. The leaf yields less than one-fifth of 1 per cent. cocaine. Fortunately only a 4 per cent. solution is used, and only a few drops of this are needed to produce the effect desired.

The new anæsthetic proves to be a great boon to ophthalmologists, and experiments are being made to extend its use to other departments of medical and surgical practice. Dentists, in particular, hope to find in it a remedial agent of value. Hypodermic injections of the 4 per cent. solution anæsthize the nervous centers. It has been used to narcotize the throat and larynx when covered with ulcers, to remove violent headaches, &c. It can well be classed among the great discoveries of the decade.

The question naturally occurs to a chemist, compiling this brief notice from various sources, how many more obscure substances await useful applications? Who dare say hereafter that the newly born chemical infant of polysyllabic name may not become a giant in strength and a blessing to Christendom?

NOTES.

Idunium is the name of a new element discovered in lead vanadate from La Plata by Prof. Martin Websky. It resembles vanadium in its reactions. (*Sitzungsb. Ak. Wiss., Berlin*, xxx, 661.)

According to L. Ricciardi, the lavas and ashes of volcanic origin contain 0.0034 to 0.013 per cent. of vanadium, and even the plants growing in the lava of Etna contain appreciable quantities of this widely distributed yet rare element. (*Gazz. chim. italiana*, XIII, 259.)

Red and yellow litharge are two varieties obtained according to temperature and treatment of the material. Geuther has studied their formation, and regards the yellow as Pb_3O_3, and the red variety as its isomer, Pb_6O_6. The yellow variety is orthorhombic and the red tetragonal in crystallization. Friction converts the former into the latter. (*Liebig's Ann. d. Chemie*, CCXIX, 56.)

The alleged transformation of brucine into strychnine by the action of hot dilute nitric acid, announced by Sonnenschein in 1875, is denied by Hanriot, who believes the strychnine pre-existed in the imperfectly purified brucine. Hanriot also finds that brucine masks the presence of

strychnine, even when the latter is present in comparatively large quantity. (*Comptes rendus*, XCVII, 267.)

A redetermination of the vapor density of ferrous chloride leads Victor Meyer to the conclusion that it consists at lower temperatures of molecules of the formula Fe_2Cl_4, and as the temperature rises these break up into molecules represented by the formula $FeCl_2$. In the experiments made the temperature reached was not sufficiently high to entirely produce the latter molecular condition. (*Berichte d. chem. Ges.*, XVII, 1335.)

Ammoniacal chloride of silver and the corresponding iodide have been obtained by M. Terreil in crystals. The ammoniacal salts were heated with a saturated solution of ammonia, in a sealed tube, to 100° C., and the silver salt dissolved, when heated, and crystallized out in needles on cooling the tube. Exposed to the air the crystals lose ammonia rapidly. (*Bull. soc. chim.*, XLI, 597.)

The composition of bleaching powder has been again investigated by Edmond Dreyfus. He comes to the conclusion that the active principle in the powder is $CaHClO_2$, and that the correct formula for the mixture is $2\ CaHClO_2 + CaCl_2 + 2\ H_2O$. It will be seen he disregards the calcium hydroxide, commonly included in the formulæ prevailing. (*Bull. soc. chim.*, XLI, 600.)

Investigations made by O. Fisher and G. Thömer on the structure of chrysaniline lead them to believe that it is a diamidophenylacridine, as they were enabled to obtain not only phenylacridine from chrysaniline, but also to produce the latter in a new way, synthetically. The material used in these experiments was Oehler's phosphine, which, after being purified, crystallizes in long, golden-yellow needles.

According to a report on the sugar beet industry by M. Pellet, there are in France 527 manufactories, of which 482 were in operation in 1883–'84. They produced 425,000,000 kilos of sugar, extracted from 6,500,000,000 kilos of sugar-beets. (*Bull. soc. chim.*, XLI, 342.)

Palmitic acid and the palmitins have been studied anew by Dr. R. H. Chittenden and Herbert E. Smith. The numerous variations in the melting points of the individual fats described lead the authors to believe in the existence of various physical modifications. (*Am. Chem. Journ.*, VI.)

Prof. Albert R. Leeds published a second memoir on the literature of ozone and peroxide of hydrogen, in which he gives a summary of the discoveries since 1878. (*Chem. News*, L, 215.)

Liquid carbon dioxide is now a commercial article, being manufactured by the *Aktiengesellschaft für Kohlensäure Industrie*, in Berlin, and sold in iron flasks containing 8 kilos of the liquid. Professor Landolt finds the liquid as sold very convenient for the preparation of solid carbon dioxide, and describes experiments with the same. (*Berichte d. chem. Ges.*, XVII, 309.)

Urea had been obtained by E. Drechsel by electrolyzing with alter-

nating currents a solution of carbamate of ammonium. The electrolysis of phenol gives rise to γ-diphenol, brenzcatechin, hydrochinon, formic acid, normal valerianic acid, oxalic acid, succinic acid, malonic acid, and other bodies not yet examined. (*Journ. prakt. Chemie*, XXIX, 229.)

Prof. Harvey W. Wiley, chemist to the Bureau of Agriculture, has devised optical methods of determining lactose in milks, which give excellent results. Details will be found in *Am. Chem. Journ.*, VI, 289.

Antonio Longi recommends paratoluidin sulphate as a delicate test for nitric acid; the latter gives rise to a red color, slowly changing to yellow. If chlorates, chromates, &c., are present, an intense blue color results; $\frac{1}{32000}$ part of nitric acid can be recognized. Diphenylamin sulphate, which yields an intense blue color, is even more sensitive, surpassing brucine in this respect.

Prof. C. L. Bloxam reports a boiler incrustation containing 0.73 per cent. of strontia. The water used in the boiler was from a deep well in the chalk at Harrow, England. Owing to an increasing demand for strontia, the author suggests chemists should be on the lookout for it. (*Chem. News*, XLIX, 3.)

In both Germany and France attention is called by chemists to a fraudulent tartar emetic found in the market, in which oxalic acid takes the place of tartaric. The true emetic contains 43.70 per cent. of oxide of antimony, while the false emetic contains only 23.67 per cent., and dyers are defrauded in proportion. (*Bull. soc. chim.*, XLI, 105.)

A detailed and interesting description of the manufacture of vermilion in China will be found in *Chem. News*, L, 77.

The International Congress of Metric Weights and Measures has adopted the following abbreviations, which are recommended for general use:

1. Measures of length: Kilometer, *km*; meter, *m*; decimeter, *dm*; centimeter, *cm*; millimeter, *mm*.

2. Surface measures: Square kilometer, km^2; square meter, m^2; square decimeter, dm^2; square centimeter, cm^2; square millimeter, mm^2; hectare, *ha*; are, *a*.

3. Measures of volume: Cubic kilometer, km^3; cubic meter, m^3; cubic decimeter, dm^3; cubic centimeter, cm^3; cubic millimeter, mm^3.

4. Measures of capacity: Hectoliter, *hl*; liter, *l*; deciliter, *dl*; centiliter, *cl*.

5. Measures of weight: Ton of 1,000 kilograms, *t*; metrical quintal of 100 kilograms, *q*; kilogram, *kg*; gram, *g*; decigram, *dg*; centigram, *cg*; milligram, *mg*.

For the abbreviations italic letters are to be used; these are not to be followed by a dot on their right, and should be written on the same line as the figures, and after the last of them, whether the number be entire or decimal.

At the meeting of the chemical section of the Association of German Naturalists and Physicians held in September at Magdeburg, Dr. Frank,

of Charlottenburg, read a paper on the technical development of the alkali industry in Stassfurt, and stated that in July, 1882, 20,000,000 cwts. of carnallite were consumed in the preparation of chloride of potassium.

The sessions of the chemical section of the American Association for the Advancement of Science at Philadelphia in September were more largely attended than at any time during the last eight years. Several eminent chemists from Great Britain were present. A new feature was the discussion of topics previously announced in a circular issued by the chairman. The section was presided over by Prof. J. W. Langley, of Ann Arbor, who made an address on chemical affinity, of great interest and value.

At the Philadelphia meeting of the American Association for the Advancement of Science, Prof. W. O. Atwater read a paper on the chemistry of fish. This embraced the results of an investigation into the economic and nutritive value of fish, and a study of the chemical constitution of the flesh of fishes and invertebrates. The flounder was found to be the least nutritive of fishes, while the salmon, when fat, was the most nutritive. Among the invertebrates the crab is the most nutritious, while the oyster is least. Speaking of oysters, the author said that those from Northern waters were more nutritious than those from the South; and the amount of nutriment in the oyster was about the same as that in milk. Digestive ferments (as pepsin, &c.) act upon the flesh of fish in the same manner as upon that of vertebrates, about 98 per cent. of the albuminoids being digested in both cases.

Prof. F. W. Clarke, chief chemist to the United States Geological Survey, has issued a report of work done in the Washington Laboratory during the fiscal year 1883–'84. The report gives results of the analyses of twenty-two rocks, minerals, and ores, and of twenty-three water analyses. The latter include waters from Montana, the Utah Hot Springs, and the Virginia Hot Springs. The water of Mono Lake, California, contains 51.85 grams to the liter total solids; that of the larger Soda Lake, near Ragtown, Nev., contains no less than 125.13 grams to the liter, the solids consisting chiefly of sodium carbonate, chloride, and sulphate. Lake Tahoe, California, sustains its reputation for purity, the water containing only 0.073 gram total solids per liter.

According to the annual report for 1884 of the Russian Chemical and Physical Society, situated in St. Petersburg, the chemical section had 162 members, its income, including several grants, reached 5,734 rubles (about $2,750), and its capital amounted to 13,932 rubles.

At the regular meeting of the *Société chimique de Paris* held May 23, 1884, it was voted, 30 to 12, to adopt a resolution looking to a change in the name of the society by substituting "France" for "Paris" in its title. A committee was appointed to carry the change into effect in a legal manner. The society numbers 468 members, and had an income in 1883 of 20,000 francs.

The *Deutsche chemische Gesellschaft* continues to prosper. At the close of the year 1884 it had 2,901 members (including 13 honorary members), having gained 170 members during the year. In 1883 the society received 535 original communications, and in 1884, 646; in 1883 it published 3,101 pages in its *Berichte*, and in 1884 3,065 pages, exclusive of abstracts, a necrology, and an index, which have an independent pagination. It received from all sources during the year 57,307 marks, and expended about 4,000 marks less. It holds productive property valued at 68,000 marks.

At the anniversary meeting of the Chemical Society (of London) held March 31, 1884, the president called attention to the fact that notwithstanding the increased number of laboratories in Great Britain, and greater facilities for the prosecution of research through the aid of the Government grant and the Chemical Society's fund, the number of papers read before the society is declining year by year.

Prof. W. N. Hartley, in *Nature*, considers somewhat at length the circumstances which have brought about this "startling and anomalous fact." In 1880–'81 the Chemical Society (of London) received from its members 113 communications; in 1881–'82, 87; in 1883–'84, 67. It is true there are seven other societies which publish chemical papers, besides two in Ireland. The Society of Chemical Industry received in the second year of its existence (1883–'84) 68 papers. It is evident that the number of communications to the Chemical Society has declined in proportion as those to the younger Society of Chemical Industry increased. Papers on industrial chemistry abound, those on pure research are relatively few, and in this respect a great contrast is offered to the work of the German Chemical Society, which publishes 3,000 pages annually of exclusively pure researches.

Professor Hartley is not willing to admit that the decline of interest in original researches is the fault of the teachers in England, though he regrets that many professors are obliged to teach several branches of science. He recognizes the influence of the requirements for the degree of doctor of philosophy in German universities upon originality of thought, but thinks this alone insufficient to account for the difference. "It is rather that which is not required which is so advantageous to students; it is the *Lehre und Leben Freiheit* which professors and pupils both enjoy." On the Continent the motive for scientific education is mental culture, while in Britain it is utilitarianism; while the former tends to the *advancement of learning*, the latter involves nothing further than the *diffusion of knowledge*.

Does not the above criticism of English culture apply to a large extent to the system of education in America?

Co-operative Indexing in Chemistry.—At the Montreal meeting of the American Association for the Advancement of Science a committee was appointed to devise and inaugurate a plan for the proper indexing of the literature of the chemical elements. This committee reported in

August, 1882; that they had considered three methods of collecting material for the indexes, viz:

1. Reviewing the Catalogue of Scientific Papers published by the Royal Society (8 vols., 4to).

2. Indexing special journals by different individuals and collating the matter.

3. The independent plan, whereby each chemist indexes all the journals available to him with reference to a given element in which he is presumably especially interested.

Each of these schemes is open to objections, which need not be named. On the whole, the third plan seemed to a majority of the committee the only feasible one for the present.

The report considers also the best arrangement of material, and three ways are suggested: (1) Chronologically; (2) alphabetically by authors; (3) topically.

The committee do not venture to dictate to volunteers and independent workers, but recommend the chronological arrangement, accompanied by a topical index.

In September, 1884, the committee reported that several indexes had been published during the twelve months intervening, and that more were in progress. They also announced that the Smithsonian Institution has consented to publish the indexes to chemical literature indorsed by the committee, limiting somewhat the number of pages per annum. The Smithsonian Institution also distributes free of expense the circulars of the committee.

The indexes already published include the following: *Uranium*, by H. Carrington Bolton, 15 pp.; *Manganese* (1596–1874), by H. Carrington Bolton, 44 pp.; *Titanium*, by Edward J. Hallock, 22 pp.; *Vanadium*, by G. Jewett Rockwell, 13 pp.; *Ozone*, by Albert R. Leeds, 32 pp.; *Peroxide of Hydrogen* (1818–'78), by Albert R. Leeds, 11 pp.; *Electrolysis*, by W. Walter Webb, 40 pp.; *Speed of Chemical Reactions*, by Robert B. Warder, 3 pp.; *Starch-Sugar*, by Edward J. Hallock, 44 pp.; *Ozone* (1879–'83), by Albert R. Leeds, 16 pp.; *Peroxide of Hydrogen* (1879–'83), by Albert R. Leeds, 3 pp.; *Dictionary of the Action of Heat upon Certain Metallic Salts*, by J. W. Baird and A. B. Prescott, 70 pp. 8vo. New York.

The first two were published in the Annals of the New York Lyceum of Natural History and all the rest in the Annals of the New York Academy of Sciences, except that on *Starch-Sugar*, which was published by the United States Internal Revenue Department, Washington, D. C.; and that on *Speed of Chemical Reactions*, which appeared in the Proceedings of the American Association for the Advancement of Science.

A limited number of those published by the New York Academy of Sciences can be had of Prof. D. S. Martin, 236 West Fourth street, New York City, the chairman of the publication committee.

The index committee consists of H. Carrington Bolton, Ira Remsen, F. W. Clarke, Albert R. Leeds, and Alexis A. Julien.

Communications should be addressed to H. Carrington Bolton, care of Smithsonian Institution, Washington, D. C.

NECROLOGY OF CHEMISTS, 1884.

J. A. BARRAL, a well-known agricultural chemist of France, the editor of Arago's works, as well as of many important agricultural journals, died in Paris in September, aged 65 years.

ADOLF VON BRÜNING died April 21, 1884. He was born January 16, 1837; Brüning was one of the founders of the important establishment for the manufacture of the coal-tar dye-stuffs, located at Höchst-am-Main, and known by the firm-name Meister, Lucius & Brüning.

OTTO BURG died November 9, 1884. He had been for many years director of large chemical works in various parts of Germany.

AMÉDÉE CAILLOT died November, 1884, aged nearly 80 years. He was for many years professor of chemistry in Strassburg, and counted among his pupils Wurtz, Willm, Schützenberger, and many other eminent men. For a fuller biography see *Bull. soc. chim.*, XLII, 610.

E. CARSTANJEN, professor of chemistry at the University of Leipsic, died in Leipsic, July 13, aged 49 years.

ROBERT ROSCOE FELIX DAVEY, born about 1842, in London, died in 1884. Since 1867 he was a fellow of the Chemical Society of London.

VICTOR DESSAIGNES, born at Vendôme, December 30, 1800, died in 1884. He was the author of much original work chiefly in physiological chemistry. He was one of the honorary foreign members of the London Chemical Society.

JEAN BAPTISTE DUMAS died April 11, 1884, at Cannes, where he had gone for his health. Dumas was born in 1800, at Alais, France, and for sixty years past has been one of the foremost chemists of France. A full biography (with portrait) was published in *Nature*, XXI, February 6, 1880.

J. P. L. GIRARDIN died early in June, 1884, in the eighty-third year of his age. He filled chairs of chemistry in Rouen, Lille, and Clermont, and published several important works.

EDWARD J. HALLOCK died March 22, at his home in Peekskill, N. Y. He was born June 19, 1845, was graduated at Columbia College in 1869, and at the University of Heidelberg in 1878. He had filled chairs of chemistry in several colleges, and was also engaged in editorial work.

A. HENNINGER died in Paris, October 4, 1884, aged 34. He held the chair of chemistry in the École Municipale de Chimie, and was one of the editors of *Science et Nature*. He was a pupil of Wurtz.

JAMES HOGARTH, born November 17, 1858, in Androssan; died in Philadelphia in 1884. He was at one time in the employ of Mr. J. B. Hannay, of Glasgow, and later of the United States Government, at Newport, R. I.

HANS HÜBNER, director of the chemical laboratory of the University of Göttingen, died in that city July 13, 1884, aged 47 years. Dr. Hübner will long be cordially remembered by many Americans who received instruction at his hands.

EDWARD HUNT, born about 1830, at Hammersmith; died August 12, 1884, in Manchester. He was an enterprising industrial chemist, and since 1851 a fellow of the Chemical Society of London.

HERMANN KOLBE died November 25, 1884, in Leipsic. Kolbe was born in 1818, near Göttingen, at the university of which city he was educated. After serving as Bunsen's assistant, in Marburg, and Playfair's, in London, he was called to the chair of chemistry in Marburg, in 1851. Since 1865 he has filled the same position in the University of Leipsic. Kolbe was a man of great activity; his contributions to organic chemistry are voluminous and valuable; his labors as editor of the *Journal für praktische Chemie* and as writer of several works, have left a lasting impress on the science of this century. For a full biography see *Chem. News*, XL, 282.

L. LICHTENSTEIN died in July, 1884. He was assistant at the agricultural experiment station in Bamberg. He was a member of the German Chemical Society.

JAMES NAPIER, a Scotch chemist, died in 1884. He was the author of several technological manuals and of a historical work entitled: Manufacturing Arts in Ancient Times, (Paisley, 1879, 8vo.). He was a member of several learned societies.

JACOB NATANSON died September 16. He was at one time professor of chemistry in the high school at Warsaw. He was the author of a text-book (in Polish) and made several original investigations.

WILLIAM HENRY ASTON PEAKE, born at Dublin, March 28, 1855, died June 28, 1883, at Cape Colony, where he filled the chair of chemistry and physics in the college at Stellenbosch.

WILLIAM PLUNKETT, born in Dublin, died in 1884. He was assistant in chemistry, under Professor Galloway. at the Royal College of Science, Dublin.

EUGENE RITTER died in July, 1884. Dr. Ritter had been professor of medical chemistry and toxicology in the School of Medicine at Nancy, France, since 1872.

ROBERT E. ROGERS died September 6, 1884. He was born in Baltimore in 1814. Until a short time before his death he held the professsorship of chemistry in the Jefferson Medical College, Philadelphia. He was the last of four brothers, all distinguished in science.

HENRY YOUNG DARRACOTT SCOTT, born in January, 1822, died in 1884. He was a major-general in Her Majesty's service, and in 1851 had charge of the chemical laboratory at Woolwich. He is best known, however, as the builder of the Royal Albert Hall, London.

ROBERT ANGUS SMITH died May 12, 1884, aged 68 years. Dr. Smith has been for forty years one of the most conscientious and zealous work-

ers in the field of chemistry in Great Britain. His contributions, especially in sanitary matters, have been most valuable. A biography will be found in *Chem. News*, XLIX, 222.

QUINTINO SELLA, born July 7, 1827, died in March, 1884. He was the author of many investigations in chemical mineralogy, and at the time of his death was one of the honorary members of the German Chemical Society, as well as president of the Accademia dei Lincei, in Rome.

STEN STENBERG, a Swedish chemist, born in 1825, died in July, 1884.

PAUL E. THÉNARD died August 10, at his residence in the Côte d'Or. He was the author of many original papers, especially in the field of agricultural chemistry.

AUGUSTUS VOELCKER died in November, aged 62, having been born September 24, 1822, at Frankfurt-am-Main. He was professor of chemistry to the Royal Agricultural Society of England, at Cirencester, a position held by him since 1859. He contributed many original papers on agricultural chemistry, and was the author of several works on the same subject.

HENRY WATTS, born in London, January 20, 1815; died June 30, 1884. He has left behind him an enduring monument in the superb "Dictionary of Chemistry" to which his name is attached. For a full biography see *Nature*, XXX, 217.

JAMES THOMAS WAY died in 1884, aged 63 years. He was eminent in agricultural chemistry, having held the position of chemist to the Royal Agricultural Society. He was the author of many original papers and a member of several learned societies.

G. W. WIGNER died in November. He was former editor of the *Analyst*, the organ of the Society of Public Analysts, and the author of a prize essay on food adulteration, a subject on which he had a wide reputation.

CHARLES ADOLPHE WURTZ died in Paris, May 12, 1884. He was born at Strasburg, November 26, 1817, and was graduated at the School of Medicine in that city in 1843. In 1845 he went to Paris, and since that date has held important positions in the Academy of Medicine and in the medical faculty of the university. His researches, especially in the field of organic chemistry, were numerous and of great influence. For a full biography see *Bulletin de la Société chimique de Paris, numéro supplémentaire*, January, 1885.

C. ZWENGER, professor of pharmaceutical chemistry at the University of Marburg, died March 15, 1884.

In addition to the long list of chemists whose decease is above noticed, the following names of members of the German Chemical Society must be briefly recorded:

H. VON BAUR, of Berlin.

J. BRANTLECHT, of Wendeburg.

R. BRIX, of Brod, Hungary.

J. H. CROSSLEY, of Widnes.
K. DIEHL, of Offenbach.
E. DIETRICH, of Helfenberg.
K. GEHRKE, of Goslar.
FRANK HATTON, of London.
JULIUS HAUFF, of Nuremberg.
IWAN HYNÉN, of Bonn.
A. W. KAHLBAUM, of Berlin.
M. KRETSCHY, of Vienna.
R. S. PAYKULL, of Stockholm.
R. SCHULTZ, of Baden Baden.
G. TELLE, of Leipsic.
J. J. VAN VALKENBURG, of Amsterdam.
GUSTAV VOLLMAR, of Biedenkopf.

And to complete the necrology of the year, we add the names of members of the Chemical Society of London, not previously noticed, who died within the twelve months ending March 30, 1885:

G. D. ATKINSON.
ADRIAN BLAIKIE.
JAMES FORREST.
ROBERT HARVEY.
J. W. HUDSON.
F. M. JENNINGS.
ROBERT JONES.
W. J. LANSDELL.
H. B. PRITCHARD.
T. K. ROGERS.
JUWANSNIGJE JARWATSNIGJE.
J. L. SHUTER.
SIDNEY GILCHRIST THOMAS.

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MINERALOGY.

By Edward S. Dana,

Yale College, New Haven, Conn.

GENERAL WORKS ON MINERALOGY.

The additions to the list of mineralogical treatises have not been numerous during the past year. Perhaps the most noteworthy is the *Text-Book of Descriptive Mineralogy*, by Mr. Hilary Bauerman, of the Royal School of Mines in London. It forms a companion volume to the Text-Book of Systematic Mineralogy, published three year ago, and noticed in the report for 1882. The present volume is devoted to the descriptions of species, which, though necessarily brief and not always as fully up to date as might be desired, are on the whole satisfactory. It is interesting to note that the figures through the work are for the most part printed from the original blocks used in the revised edition of Phillips's Mineralogy, prepared by Brooke and Miller in 1852, a volume to which every working mineralogist now refers almost daily, notwithstanding the fact that it was prepared so many years since. An elementary text-book of mineralogy has been published in Germany by Dr. H. Baumhauer, which deserves mention, though of modest proportions. Dr. Weisbach has issued a new edition of his *Synopsis Mineralogica*,* which gives a summary of mineral species, arranged according to their chemical composition, with notes as to their crystalline form and some other points. More important than this last work is the opening portion (first 80 pages) of the ninth volume of the *Materialien zur Mineralogie Russlands*, by N. v. Kokscharow. The species treated at length in this part are caledonite and wollastonite, but supplementary notices are also given of monazite, rutile, pachnolite, and xanthophylite; the whole work is a monument of careful and accurate labor.

A large volume (630 pages) has been published, under the editorship of Dr. J. B. Marvin, of the *Original Researches in Mineralogy and Chemistry* of the late Dr. J. Lawrence Smith. Dr. Smith was for many years one of the most active contributors to these sciences in the United States,

* For the full title of this and other works, see the Bibliography at the close of this article.

and it is well that these, his most important papers (numbering nearly one hundred), should be put in permanent form. The volume contains also biographical sketches by Dr. Marvin, Dr. Michel, and by the late Professor Silliman.

Of the works devoted to special departments of mineralogy the *Traité de Cristallographie* of Professor Mallard, of the École des Mines in Paris, must be mentioned first. The first volume of this most valuable work was issued in 1879, and the second has followed during the past year. The two volumes embrace upward of a thousand pages, and an atlas with numerous plates accompanies them. It is the most exhaustive treatise upon crystallography and physical mineralogy which has been published in many years, and covers some branches of the subject more fully than has ever been done before. Dr. Aristides Brezina, of Vienna, has published the first part of a work entitled *Krystallographische Untersuchungen an homologen und isomeren Reihen*, a memoir which has received the Baumgartner prize from the Vienna Academy. This part is devoted to a discussion of the methods of observation, measurement of crystals, &c., and also the methods of calculation. These topics are discussed with almost an excess of fullness of detail. Dr. Eugen Hussak, of Graz, has issued a work entitled *Anleitung zum Bestimmen der gesteinbildenden Mineralien*, which promises to be of value to those who are especially interested in the application of mineralogy to petrography. The excellent tables for the determination of minerals prepared by von Kobell, and of which 11 editions were issued before the death of the author, have been revised by K. Oebbeke, and a 12th edition published, with the additions which the rapid development of the science has made necessary.

The *Encyclopédie Chimique*, published at Paris under the direction of M. Frémy, contains two volumes which are interesting to the mineralogist. The first of these is by L. Bourgeois, on the artificial production of minerals. This is a subject to which French chemists have made important contributions and upon which we already have an excellent French work (1882) by MM. Fouqué and Lévy. This new volume is a valuable contribution, giving with unusual fullness the methods employed in the synthesis of minerals, with figures of the apparatus employed, and then the special results obtained in the case of the different mineral species. Another volume of this encyclopedia, by M. Meunier, is devoted to the subject of meteorites. This is a large volume, profusely illustrated, and covering the whole subject very thoroughly.

A second part has been published of the work, by Tschermak, mentioned in the last volume of this report, devoted to the illustration of the microscopic structure of meteorites. This part contains eight plates devoted to olivine, bronzite, augite, and plagioclase, &c. They show most satisfactorily the peculiar radiated structure which characterizes these minerals when forming the spherical grains so common in the chondritic variety of meteorites.

Mr. G. F. Kunz has issued in separate form the chapter prepared by him, on *American Gems and Precious Stones*, for the Mineral Resources of the United States of Mr. A. Williams. A popular volume, entitled *Leisure Hours Among the Gems*, has appeared from the pen of Mr. A. C. Hamlin. Dr. Fletcher's *Guide to the Mineral Gallery of the British Museum*, with an introduction to the study of minerals, is a work of some interest even to those who are not so fortunate as to have the opportunity to study the beautiful collection of minerals at South Kensington.

CRYSTALLOGRAPHY AND PHYSICAL MINERALOGY.

Many contributions have been made to our knowledge of the crystalline form of different mineral species, and numerous additions have been made to the already long lists of known planes. Only a few memoirs of more than ordinary scope and interest will be mentioned. Two extended articles on this branch of mineralogy have been published by H. A. Miers, of the British Museum. One of these (*Min. Mag.*, v, 325) is devoted to the description of crystals of meneghinite from Bottino, near Serravezza, in Tuscany. The same subject was a little earlier discussed by Krenner, in the Proceedings of the Hungarian Geological Society. The results of the two investigations agree closely, they prove that the species is to be referred to the orthorhombic system; not monoclinic, as has been hitherto assumed. The crystals are highly complex in form. A second paper by Miers is a monograph of the species bournonite (*Ib.*, VI, p. 59), in which the author reviews the work of earlier crystallographers, from the time of Bournon (1804) down. To the list of 50 forms already identified, Miers adds twenty-nine new ones, determined beyond doubt, and twenty-one others, which are of rare occurrence and need confirmation. Miers accepts the elements of Miller (1852), and from these calculates a list of upwards of one thousand angles, being the angles between the normals of all the known planes and the most important planes of reference. The memoir is accompanied by two plates, with numerous figures, and a spherical projection.

Another monograph is by W. J. Lewis, of Cambridge, on miargyrite (*Zeitsch. Kryst.*, VIII, 545), which adds much to our knowledge of the complex crystals of that rare species, and removes some doubtful points about them. The paper contains a large number of figures and a long list of measured angles compared with the angles calculated from the accepted elements. A paper by Max Schuster (*Min. Petr. Mitth.*, VI, 301), on the structure and character of the crystalline surfaces of the Swiss danburite, certainly leaves nothing unsaid on that subject. It covers upwards of two hundred pages, and is the second part of a memoir, the first of which was published a year ago. The detailed description of the vicinal prominences on the planes, and all the other peculiarities, especially in their influence upon the inter-facial angles measured with the reflecting goniometer, is not without interest, but the

subject would seem to be a little overdone when two hundred and seventy-five pages are given to its discussion. Schuster, after a very careful comparison of the angles measured by him on the Swiss crystals, confirms the conclusion of Hintze that they have almost identically the same axial relations as the crystals from Russell, N. Y. Of other papers devoted to a similar class of subjects may be mentioned one by P. W. von Jeremejew on Russian linarite (abstract in *Zeitsch. Kryst.*, IX, 430); another by C. Morton on the stephanite of Kongsberg, Norway (*Œfversigt K. Vet. Akad. Förh.*, February 13, 1884), on the amphibole of the Aranyer Berg by Franzenau (*Zeitsch. Kryst.*, VIII, 568), on epistilbite by Hintze (*ib.*, p. 605), on andalusite and topaz by Grünhut (*Ib.*, IX., 113). Solly has described (*Min. Mag.*, VI., 80) a crystal of tourmaline from Pierrepont, N. Y., which showed a tetartohedral development of the scalenohedral planes; the matter needs confirmation.

Hj. Sjögren has settled (*Œfv. K. Vet. Akad. Förh.*, April 9, 1884) finally, it would seem, the disputed crystalline form of graphite, a species which has generally been referred to the hexagonal system in accordance with the early observations of Kenngott, but which was afterwards made monoclinic by Nordenskjöld. Finding the direct determination of the form by accurate measurement impracticable, because of the imperfection of the crystals, he attacked the problem indirectly. He shows that the etching figures and the figures produced by partial combustion, also the isothermal curves, all agree with the hexagonal system.

The subject of the double refraction of minerals, isometric in geometrical form, has received some important contributions during the past year, and we now seem to be approaching to a full understanding of the true relations. A few years ago it appeared as if the only species of those formerly included in the isometric system, which were likely to be allowed to remain there, were those which from their opacity (like galena) did not allow of an optical examination, so general a phenomenon had this anomalous double refraction been shown to be. The new light recently thrown upon the subject has come from the observation of Mallard, that boracite loses all its double refraction and becomes isotropic at a temperature of 265° C. To appreciate the significance of this it is necessary to recall the fact that while the geometrical form of boracite crystals is in strict accordance with the requirements of the isometric system, sections examined optically uniformly show double refraction, the section being seen to be divided, when examined in polarized light, into parts more or less regularly arranged, with different optical orientation. Instead of assuming, then, that the crystalline form is only a case of pseudo-symmetry, an imitative, or "mimetic" (to use Tschermak's word) form due to the complex twining of a number of orthorhombic crystals, we must conclude that the isometric form was the original one, and that the conditions under which the crystals were formed were similar to those we now obtain by an elevation of temperature to 265° C. Under these conditions of formation then

the molecular structure was isotropic, and the geometric form and optical character were in harmony with each other. Under present conditions, however, the molecular structure is anisotropic, double refraction has arisen from secondary causes, while the geometric form remains unchanged—form and optical properties being then contradictory to each other. This subject has been discussed by Klein (*Jahrb. Min.*, 1884, I, 235), and he describes the best methods of observation in order to show this change from the isotropic to the anisotropic state and back again. Mack has discussed at length (*Wied. Ann.*, XXI, 410) the pyro-electricity of boracite, and shows the close relation which exists between the electrical and the optical phenomena.

It will be inferred from what has been said about boracite that a similar explanation of the optical anomalies in other crystals may be expected to be found to hold true, although it is not to be supposed that this is the only cause of the secondary double refraction shown by so many minerals. Klein has extended his observations to a number of other species, the most important of which is leucite. This species, though long known to show more or less distinct double refraction, was included in the isometric system until vom Rath (1873) showed that the form could be interpreted as tetragonal; since then most mineralogists have accepted vom Rath's conclusion. It is now shown by Klein (*Nachrichten K. Ges. Wiss. Göttingen*, May 3 and August 2, 1884) that at an elevated temperature leucite also loses its double-refraction and becomes isotropic, and on cooling again becomes anisotropic, though the structure was somewhat altered. From this observed fact, he naturally concludes that at its formation the conditions were such that the mineral was isometric in form and its molecular structure correspondingly isotropic.

The memoir by Klein on leucite is a model of careful, accurate work. In his introduction he describes the special form of microscope employed, which had been constructed according to his plan, and which was in many respects an improvement upon earlier forms (as that of Bertrand) made with the same object of allowing exact optical determinations. The material under examination was ample, embracing crystals from a variety of occurrences, and, of these, some 350 thin sections were prepared. Without going too far into details, it is enough to state the general conclusions, that in form and optical characters leucite corresponds to the orthorhombic system (as first urged on geometrical grounds by Weisbach), but approximates closely to the tetragonal. The structure is in general that of a complex twin, three fundamental individuals crossing each other, which may or may not be equally developed; in some cases, one of these may predominate over the others. These individuals are twinned parallel to the planes which on the old view would have been called a dodecahedral plane. A good deal of irregularity is observed in the angles, both crystallographic and optical; it is found, moreover, that the inclusions do not correspond in their distri-

bution to the optical limits of the individuals; from these and other similar facts, together with the most important point of all, that mentioned above, that the crystals become isotropic at a high temperature, he reaches the conclusion stated, that the orthorhombic form and anisotropic optical characters are both of secondary origin. This view seems all the more probable in the case of leucite, since we know that it must have been formed at very high temperatures, an assumption which is not so natural for boracite, although we know here that artificial crystals formed at a high temperature were originally isometric and isotropic, though losing the optical simplicity at ordinary temperatures. Increase of temperature is not the only change of conditions, however, which may bring about a change of optical characters. It has recently been shown by Mallard and Le Chatelier (*Bull. Soc. Min.*, VII, 478), that hexagonal silver iodide, which becomes isotropic at a temperature of 146° C., undergoes the same change at ordinary temperatures (20°C.) if subjected to a pressure of 2,500 kilograms per square centimeter. A mineral, then, which has crystallized at a high temperature, or under a great pressure, or both, may have taken a form which does not correspond to its molecular structure under ordinary conditions of pressure and temperature. This change may manifest itself in optical character alone (as boracite) or in this and in geometrical form as well, as in leucite.

Some other contributions to the same subject deserve to be mentioned. Merian has proved (*Jahrb. Min.*, 1884, I, 193) that crystals of tridymite, which in optical character correspond, as shown by Lasaulx, to complex triclinic twins, become normally uniaxial in accordance with their hexagonal form at an elevated temperature. Analcite underwent considerable change in optical character when heated, although it did not become completely isotropic. Merian did not succeed with leucite, but Penfield (*Jahrb. Min.*, 1884, II, 224) confirms Klein's results in this respect, though he shows that elevation of temperature does not remove the optical anomalies of garnet.

Klein has also shown (*Jahrb. Min.*, 1884, II, 49) that aragonite, a mineral which is optically biaxial and orthorhombic in form, though often imitating hexagonal forms by twinning, becomes uniaxial upon heating, the section changing into an aggregate of uniaxial particles with negative double refraction. In other words, the molecular change brought about in aragonite by elevation of temperature corresponds to a change of aragonite to calcite. It may be remembered that G. Rose showed a long time since that the powder into which heated aragonite separated was probably calcite, as suggested by its lower specific gravity. A similar optical change takes place, according to Mügge (*Jahrb. Min.*, 1884, I, 63), in leadhillite (monoclinic) upon carefully raising its temperature. These results recall the discussion of a similar subject by Prof. J. P. Cooke, in his paper on the vermiculites (1873), and later in that on haloid compounds of antimony (1877). Cooke shows that at a moderate temperature (about 114° C.) the yellow orthorhombic antimony

iodide changes suddenly to the red hexagonal, and he argues that true hexagonal structure may result from molecular twinning of orthorhombic molecules.

Other investigators have worked on the same subject, of the change produced by elevation of temperature. Doelter (*Jahrb. Min.*, 1884, II, 217) has experimented upon vesuvianite, apatite, and tourmaline. W. Klein, of Bonn, has published an extended paper (*Zeitsch. Kryst.*, IX, 38), in which he gives the results of similar experiments with apatite, quartz, apophyllite, zircon, iolite, heulandite, and other minerals. Förstner (*Ib.*, p. 333) gives the results of a very interesting series of experiments upon the changes in optical characters brought about by artificial change of physical conditions on the feldspars of Pantelleria. These lead to essentially the same conclusions as the experiments of Klein on boracite and leucite. Among other things Förstner says, with respect to microcline-albite, that, considering the volcanic origin of the feldspars, it is natural to conclude that at the time of its formation the conditions as to temperature, &c., were such as to cause a monoclinic arrangement of the particles, and that the present (triclinic) optical characters are the result of subsequent changes.

From a theoretical standpoint, perhaps the most interesting and suggestive contribution to this subject is a paper by Mallard (*Bull. Soc. Min. France*, VII, pp. 349–401), in which he discusses the probable molecular arrangements in the different types of crystals and the changes which they undergo under changes of conditions, as of temperature, &c. He calls attention to the cubic type, and the fact that the crystals of other systems often approximate to it; and, moreover, that the crystalline parameters of a very large number of crystals are simple multiples (1, 2, 3) of the parameters of the cubic "réseau." From this he concludes that for all crystals, without exception, the réseau formed by the centers of gravity of the molecules is the same, and very nearly that which characterizes the cubic "réseau." The relatively slight differences which exist between this last and the one actually existing could constitute with the special molecular twinning, and the molecular volume, the crystalline individuality peculiar to each substance. This molecular twinning, which heat and other causes can alter, is regarded as giving rise to the true crystalline molecules. Reference must be made to the original paper for the full discussion of the subject.

Des Cloizeaux has continued his investigations of the optical characters of the feldspar species. A recent paper (*Bull. Soc. Min.*, VII, 249) is devoted to oligoclase and andesine, and covers nearly 100 pages, giving a large number of determinations of the position of the axes of elasticity, measurements of the axial angles, and so on. His observations go to show that, in the albite-anorthite series of plagioclase, the species or subspecies andesine deserves a more definite place than many mineralogists have of late years been inclined to give to it. It may be added here that Gylling has recently described (*Jahrb. Min.*,

1884, II, 19 ref.) good crystals of andesine from Orijärvi in Finland. J. H. Kloos has contributed (*Jahrb. Min.*, 1884, II, 87) a series of optical observations on orthoclase and microcline. He concludes that the two species are thoroughly distinct, orthoclase being strictly monoclinic and microcline triclinic, although the latter by very fine twinning may imitate the monoclinic mineral. He does not support the view which has been advanced that orthoclase is nothing but a mimetic microcline. The observations of Förstner (see above) bear upon this subject.

Of researches bearing upon the cohesion in crystallized substances two new papers by Mügge must be referred to (*Jahrb. Min.*, 1884, I, 50, 216). Becke discusses at length the etching-figures on galena (*Min. Petr. Mitth.*, VI, 237).

CHEMICAL MINERALOGY.

Of contributions to the general subject of chemical mineralogy several papers by Rammelsberg deserve to be mentioned first. These are devoted to the discussion of some points bearing on the isomorphism of minerals (*Jahrb. Min.*, 1884, II, 67); on the chemical relations of the natural borates (*Ib.*, p. 158). Blomstrand discusses (*Geol. För. Förh., Stockholm*, VII, 59) the composition of the native compounds of uranium. An important paper by Doelter and Hussak (*Jahrb. Min.*, 1884, I, 18) deals with the action of a melted rock upon different minerals, with a view to throwing light upon the contact phenomena observed in nature. Fine pulverized rock, as basalt, andesite, or phonolite, was melted in a porcelain crucible, and then the mineral to be experimented upon was inserted into the molten mass. The minerals chosen for the experiment were pyroxene, hornblende, biotite, feldspar, olivine, quartz, garnet, iolite, and zircon. The results of the experiments are not without interest, though of too special a character to be detailed here; they do not lead to any broad conclusions. Another paper (*Ib.*, p. 158) by the same authors describes the results of trials with different varieties of garnet and vesuvianite, these minerals being fused and the products resulting from the recrystallization of the melted material studied. For example, melanite yielded in this way meionite, anorthite, and a variety of olivine; grossularite, from Wilui, gave meionite, a little anorthite, a mineral like melilite and perhaps hematite, and so on. The original mineral was not reproduced, and, moreover, the fusing together of nephelite and augite, and also of meionite and olivine, failed to yield garnet. Doelter has also made an interesting series of synthetic experiments (*Ib.* II, p. 51, *Zeitsch. Kryst.*, IX, 321) on the pyroxenes and nephelite, the results of which deserve to be studied in detail.

In the line of chemical studies of individual mineral species, Penfield's paper on the composition of beryl (*Amer. Jour. Sci.*, XXVIII, 25) is perhaps the most interesting. The formula of beryl, as previously accepted, was that of a simple bisilicate of aluminum and beryllium, and the only uncertainty surrounding it was supposed to be that connected

with the question as to the true atomic weight of beryllium. Penfield has made a series of careful analyses on pure specimens of beryl from seven different localities, and shows by them that beryl uniformly contains both alkalies and basic water, which earlier analysts have overlooked. Thus the Hebron, Me., beryl contains nearly 3 per cent. of cæsium oxide, with 1 per cent. lithia and 1.8 soda and 2.3 water. The beryl from Branchville, Conn., contains 1.5 per cent. of soda and 0.7 lithia, with 2.7 water, and that of Aduntschilon, Siberia, contains 0.25 per cent. soda and 1.1 water. The true formula of the species must, therefore, take account of both alkalies and water, but additional chemical work is needed to establish it thoroughly. Another point of interest is the identity of the rare mineral, scovillite, from Salisbury, Conn., with the even rarer rhabdophane from Cornwall. A paper by Brush and Penfield (*Ib.*, XXVII, 200) discusses this subject, and shows that the mineral is essentially a hydrous phosphate of yttrium, erbium, lanthanum, and didymium.

A new analysis of the haydenite of Baltimore has been made by Morse and Bayley (*Amer. Chem. Journ.*, VI., 24), which proves that the earlier analysis was incorrect, and that it is, as has been assumed, identical with chabazite. A hydrous sulphate of manganese and aluminum from Sevier County, Tennessee, has been investigated by W. G. Brown (*Ib.*, p. 97). It is shown not to correspond exactly to any of the known sulphates, though related to the afjohnite of South Africa and bosjemanite of several localities. The same chemist has analyzed the cassiterite from Irish Creek, Rockbridge County, Virginia (*Ib.*, p. 185). Messrs. Clarke and Chatard have published (*Amer. Jour. Sci.*, XXVIII, 20) analyses of a series of minerals from different localities, including allanite from Topsham, Me., some jade-like minerals, the material of Eskimo implements collected at Point Barrow, Alaska, &c. Renard and Klement have a paper in the Bulletin of the Royal Academy of Belgium (November 8, 1884) on the chemical composition of crocidolite and fibrous quartz of South Africa.

NEW MINERAL LOCALITIES IN THE UNITED STATES.

The most interesting discovery of the past year is that of the rare mineral herderite at Stoneham, Me., a locality which has already furnished fine crystals of topaz and a number of other interesting minerals (see the Report for 1883). The original herderite was described by Haidinger in 1828, from a specimen from the tin mines of Ehrenfriedersdorf, in Saxony. The form was then made out fully, but the composition was left uncertain, there being only some blowpipe trials made, according to which it was decided to be probably a fluo-phosphate of aluminum and calcium. Only three or four specimens have been known to exist, and from 1828 till 1884 nothing was added to our knowledge of the species. Now, however, it has been found, as first described, by

W. E. Hidden (*Amer. Journ. Sci.*, XXVII, 73), at Stoneham, and in sufficient quantities to allow of its thorough study. The crytalline form has been found to be near that of the original mineral (*Ib.*, p. 229), and also its optical characters (*Bull. Soc. Min., France*, VII, 230). An analysis was made by J. B. Mackintosh (*Amer. Journ. Sci.*, XXVII, 135), which resulted in proving that it was a fluo-phosphate of beryllium and calcium. Some doubt was thrown upon this determination by analyses by Winkler (*Jahrb. Min.*, 1884, II, 134), on both the Maine mineral and that from the original Saxon locality. The analyses of Winkler, however, were made upon minute quantities, and have since been proved by Genth to be inaccurate (*Amer. Phil. Soc.*, October 17, 1884), Genth's results confirming those of Mackintosh most fully and establishing the identity of the two minerals.

Another mineralogical discovery of hardly less interest is that of the beautiful new borate called colemanite, a description of which is given among the new species beyond. The new Colorado minerals, zunyite and guitermanite, are also mentioned in the same place.

Dr. Hillebrand has described a number of mineral occurrences which present points of novelty. One paper (*Amer. Journ. Sci.*, XXVII, 349) contains an account of an unusual variety of nickeliferous löllingite occurring in complex twin crystals, from Teocalli Mountain, on Brush Creek, Gunnison County, Colorado; of a variety of cosalite containing 8.4 per cent. of silver and 7.5 per cent. of copper, from the Comstock mine near Parrott City, La Plata County; of a sulphide of bismuth, silver and copper, perhaps new, from the Missouri mine, Hall's Valley, Park County; of hübnerite, from the Uncompahgre district, Ouray County, and also from Phillipsburg, Montana.

Another paper by the same author (*Proc. Colorado Sci. Soc.*, I, 112), contains descriptions of a number of rare minerals, the majority new to America, from the American Eagle mine, Tintic district, Utah. These are olivenite in fine crystals, also in the brown compact fibrous form called wood copper; conichalcite in emerald-green globular forms, with radiated structure; chenevixite, in olive-green to greenish-yellow, compact masses imbedded in the ore; also jarosite and a hydrous calcium arsenate in fine, silky, white needles. He also describes bindheimite from Secret Cañon, Nevada; zinckenite from the Brobdignag mine, Red Mountain, San Juan County, Colorado; and the rare nickel telluride melonite from Boulder County, Colorado. Mr. Richard Pearce mentions (*Ib.*, p. 111) the occurrence of native bismuth with bismutite from Cummins City, North Park, Colorado. The same volume of Proceedings referred to also contains a list of the important minerals of Colorado, with localities, prepared by Mr. Whitman Cross.

Prof. W. P. Blake has described the occurrence of gigantic crystals of spodumene at the Etta tin mine in Pennington County, Dakota. One crystal is spoken of penetrating massive quartz and feldspar, which was 36 feet long and from 1 to 3 feet in thickness. At the Ingersoll claim,

in the same region, the same writer mentions the occurrence (*Am. J. Sci.*, XXVIII, 341) of crystallized masses of a mineral which appeared to be columbite. One mass weighed by calculation about a ton. This mineral is probably in fact tantalite, for an analysis of a similar mineral from the same locality by C. A. Schaeffer proved it to contain 79 per cent. tantalum pentoxide; moreover, the specific gravity was 7.72; that of typical tantalite ranging from 7 to 8, and of ordinary columbite from 5.4 to 6.5. Fine crystals of vanadinite are described by F. H. Blake (*Ib.*, XXVIII, 145), from the Black Prince mine, Pioneer mining district, Pinal County, Arizona. They vary in color from yellow to deep red, the latter being the most common; wulfenite also occurs at the same mine, but not in very perfect crystals. S. B. Newberry (*Ib.*, XXVIII, 122) mentions the discovery of nickel ore in large quantities in Cottonwood Campus, Churchill County, Nevada. The specimens obtained from a depth of 80 feet were pure massive niccolite; these from depths of 60 feet and 45 feet showed more or less oxidation and hydration; and specimens from near the surface consisted of annabergite, the hydrated arsenate of nickel.

An interesting occurrence in New Jersey is mentioned by Prof. Geo. H. Cook in his annual report of the Geological Survey, that of grains of metallic iron in the triassic red shales near New Brunswick. They were brought up by a drill used to bore a deep well, and were found also in the surface soil—the correctness of the observations is regarded as being above doubt. Prof. H. Carvill Lewis has given a preliminary account of an interesting mineral occurring in tetragonal crystals in calcite at Wakefield, Canada. It has the form of sarcolite, but a microscopic examination has proved it to be an altered mineral pseudomorph, after some original mineral, which has not yet been found at the locality. In occurrence and relations it is suggestive of the gehlenite from the Tyrol. The name *cacoclasite* was suggested for it, in allusion to the absence of cleavage, before its pseudomorphous character was established. The same author describes a variety of dark-bluish spinel, also from Wakefield; it is remarkable for having an approximately cubic form, the planes, however, being much rounded. Barite crystals from DeKalb, Saint Lawrence County, New York, have been described by Dr. Geo. H. Williams. From Topsham, Me., Prof. F. C. Robinson has obtained crystals of allanite (*Amer. Jour. Sci.*, XXVII, 412), which he has subjected to chemical analysis. Additional points of interest are the occurrence of kaolinite in microscopic crystals, showing pyramidal planes, at the National Belle mine at Red Mountain, Ouray County, Colorado, as noted by R. C. Hills (*Ib.*, XXVII, 472); also the occurrence of leucite in lava in the vicinity of the volcano, Cerro de las Virgines, in Lower California.

NEW MINERALS.

Aimafibrite, Aimatolite.—See Hemafibrite, Hematolite, below.

Allaktite.—This is one of a group of manganese arsenates recently discovered in Nordmark, Sweden. This group includes allaktite, dia-

delphite (or aimatolite=hematolite), hemafibrite (aimafibrite), synadelphite. From this locality comes, too, manganostibiite, a related mineral containing also antimony, and xanthoarsenite is still another manganese arsenate (and antimonate) from a different Swedish locality. As announced by A. Sjögren, allakite occurs in small crystals, rarely 4 by 2^{mm} in length and breadth, tabular parallel to the orthopinacoid. They occur in cavities and druses, in a manganese calcite, together with fluorite, pyrochroite, chrysolite, &c. The crystals, which are fully described by H. Sjögren, are monoclinic in form and closely related to pharmacolite and vivianite. They are quite complex, showing some fifteen different planes, half of them in the prismatic zone; the optic axes lie in the plane of symmetry. The hardness is 4 to 5, the specific gravity 3.83 to 3.85. The crystals are strongly pleochroic, with blood-red, yellow, and bluish-green as the axial colors. The luster is vitreous, transparent to translucent; the fracture is splintery. An analysis leads to the formula $Mn_3As_2O_8 + 4\ H_2MnO_2$. (*Geol. För. Förh., Stockholm*, VII, 109, 220, 407.)

Bröggerite.—This name has been given by Blomstrand in honor of the Norwegian mineralogist, W. C. Brögger, to a uranium mineral, near cleveite in composition—cleveite, it will be remembered, is closely allied to uraninite or pitch-blende. The specimen examined by Blomstrand was from the neighborhood of Moss, Norway. It formed part of an octahedral crystal; the mineral, consequently, like the others named, is to be referred to the isometric system. The hardness was 5 to 6, the specific gravity 8.73, and the color iron black. An analysis showed it to consist of about 80 per cent. of the oxide of uranium, with 8½ per cent. of lead oxide, 5½ per cent. of thorina, and small quantities of other elements, including the cerium yttrium metals. The author accompanies his description of this mineral with an extended discussion of the various minerals containing uranium. (*Geol. För. Förhandl., Stockholm*, VII, 59.)

Colemanite.—This is a new mineral of rare beauty and perfection of form. It was first described by J. T. Evans, and named by him after William T. Coleman, of San Francisco. Later the crystalline form has been exhaustively studied by Jackson, and other contributions have been made by mineralogists abroad. As shown by the analyses of Evans, it is a hydrous borate of calcium, having the formula 2 CaO, $3B_2O_3 + 5\ H_2O$, and very closely related to (if not identical with) the priceite from Oregon and pandermite from the Black Sea. It occurs in splendent crystals, sometimes attaining a size of 30^{mm}, lining cavities in the massive mineral. They belong to the monoclinic system, and have perfect clinodiagonal cleavage. In habit the crystals are near datolite, and a hasty examination of them might lead to their being referred to that species. The crystals are very highly modified, about forty different forms having been observed, half of them on a single crystal. The hardness is about 4 and the specific gravity 2.43. The crystals vary

from white to clear and colorless; the massive mineral is white. The locality of this beautiful borate is in Southern California, in the Calico district, San Bernardino County, and Death Valley, Inyo County. (*California Acad.*, Bulletins Nos. 1 and 2.)

Diadelphite.—This name was given by H. Sjögren to a manganese arsenate from the Moss mines in Nordmark, Sweden, and simultaneously the same mineral was announced by Igelström under the name aimatolite (properly hematolite). In its method of occurrence it is like allaktite described above. The crystals are small, from a fraction of a millimeter to 2^{mm}. In form they belong to the rhombohedral division of the hexagonal system, but optically they show anomalies, and Bertrand calls them pseudo-hexagonal. The color is brownish-red to garnet-red, the streak light chocolate brown. The crystals become superficially oxidized easily, and then turn black and opaque. The hardness is 3.5. The name refers to the close relation the mineral bears to synadelphite and the other manganese arsenates from Nordmark. (*Geol. För. Förh.*, *Stockholm*, VII, 210, 233, 369, 407; *Bull. Soc. Min. France*, VII, 121, 124.)

Goyazite.—A new hydrous phosphate of aluminum and calcium, described by Damour, from the diamond-bearing gravels of the province of Minas Geraës, Brazil. It occurs in small rounded grains of a yellowish-white color, showing one cleavage, normal to which the black cross of a uniaxial crystal can be observed in the polariscope. The hardness is 5, the specific gravity 3.26. The name refers to the province where the principal diamond deposits occur. (*Bull. Soc. Min.*, VII, 204.)

Guitermanite.—A name given by W. F. Hillebrand, after Mr. Franklin Guiterman, to a new metallic sulphide from the Zuñi mine, near Silverton, San Juan County, Colorado. It occurs intimately mixed with zunyite (see below). When in the fresh state it has a bluish-gray color and slight metallic luster. The hardness is about 3, the specific gravity 5.94. The formula deduced, after deducting the impurities present in the material analyzed, is 10 PbS, 3 As_2S_3.

Hemafibrite (*or Hœmafibrite*).—Another of the new manganese arsenates from Nordmark, Sweden, described by Igelström, and named in allusion to its color. It occurs in globular forms, with fibrous structure, mixed with magnetite and serpentine. According to Bertrand the mineral is orthorhombic, with the acute positive bisectrix parallel to the prismatic edge, and an optic axial angle of 70°. The color is blood-red, to which the name given refers. Its composition is near that of allaktite, but it contains more water. (*Geol. För. Förh.*, *Stockholm*, 210, 407; *Bull. Soc. Min. France*, VII, 121, 124.)

Hematolite (*or Hœmalolite*).—The proper form of the name aimatolite, given by Igelström to the mineral also called diadelphite (which see) by H. Sjögren. References as for hemafibrite above.

Hillangsite.—Described by Igelström as a new mineral, but probably only a variety of amphibole. It is said to resemble the anthophyllite

from Texas, Pa. It is properly colorless and transparent, but some times has a black metallic color from included microscopic crystals of magnetite. The luster is silky. The hardness is 6. It is difficultly fusible to a black magnetic slag. An analysis makes it a bisilicate of iron and manganese, with a little magnesium and calcium. The locality is the iron mine of Hillang, Ludvika parish, Sweden; it occurs with garnet, magnetite, and igelstromite. (*Bull. Soc. Min.*, VII,232.)

Koninckite.—Described by Cesàro as a new hydrated phosphate of iron, corresponding to the formula $Fe_2P_2O_8 + 6\ H_2O$. It occurs in small globular or semi-globular forms, consisting of radiating needles, which are translucent and almost colorless, and are to be referred to the monoclinic system. It has a vitreous luster, a hardness of 3.5, and a specific gravity of 2.3. It fuses readily to a black bead. Koninckite is found with the fluo-phosphate of iron, richellite, recently described by the same author at Visé, Belgium. It is named after Prof. De Koninck, of Liège. (*Ann. Soc. Geol. Belg.*, XI, 247.)

Manganostibiite.—Still another new mineral from Nordmark, Sweden. According to Igelström, it occurs in black grains, probably to be referred to the orthorhombic system. These are found in crystalline limestone with other manganiferous minerals, as hausmannite, pyrochroite, allaktite. An analysis leads to the formula $5\ MnO\ (Sb, As)_2\ O_5$, with the antimony predominating. The name refers to its composition as containing both manganese and antimony (stibium). (*Geol. För. Förh., Stockholm*, VII, 210; *Bull. Soc. Min. France*, VII, 120.)

Polylithionite.—A variety of lithia mica described by Lorenzen as occurring at Kangerdluarsuk, Greenland, with rinkite (see below), arvedsonite, ægirite, eudialyte, &c. It is found in pale green to white six-sided tabular crystals. These are divided, after the manner of zinnwaldite, into six sectors, with striations diverging from the center; the optical characters are also very near those of zinnwaldite. In composition it shows a higher percentage of silica and lithia, less alumina, and almost no iron. The name has reference to the large amount of lithium. (*Zeitsch. Kryst.*, IX, 251.)

Rinkite.—Associated with the lithia mica just described, and with the other minerals named, is a mineral to which Lorenzen has given the name rinkite, after Dr. Rink. It occurs in monoclinic crystals, tabular in habit, parallel to the orthopinacoid. The color of the fresh mineral is yellowish-brown, but the crystals are often slightly altered on the surface, and these straw-yellow. The luster is vitreous to greasy. The hardness is 5, the specific gravity 3.46. An analysis shows it to be a titano-silicate of the cerium metals and calcium with sodium fluoride. (*Ibid.*)

Salmite.—This is a manganesian variety of chloritoid from Vielsalm, Belgium, described by Eug. Prost. It occurs in irregular masses with coarse saccharoidal structure and grayish color. The hardness is 5 to 6, and the specific gravity 3.38; this determination, however, is a little low, in consequence of admixed quartz. An analysis shows the pres-

ence of 7 per cent. manganese protoxide, which is the only distinguishing feature of the variety. (*Geol. Soc. Belg.*, 1884.)

Synade'phite.—A new arsenate of manganese from Nordmark, Sweden, described by H. Sjögren. It occurs sometimes with scheelite, sometimes in cavities in the porous calcium carbonate. The crystals belong to the monoclinic system, and are very near liroconite in angle; also not far off from lazulite. The color is blackish-brown to black, being considerably darker than that of the other manganese arsenates described from the same locality; it is translucent to nearly opaque. The luster is vitreous on the fracture, submetallic on crystalline faces. The hardness is 4.5, the specific gravity 3.46 to 3.50. The composition is stated to be that of a hydrated arsenate of manganese, with also alumina and iron, being near that of diadelphite, from which, however, it differs in containing less water. The crystalline forms of the two species are also distinct. The name has reference to the close relation to diadelphite and the other allied species from the locality. (*Geol. För. Förh., Stockholm*, VII, 235, 382, 407.)

Utahite.—A mineral from the Eureka Hill mine, in the Tintic district, Utah, described by Arzruni. It occurs in fine scales forming an aggregate with silky luster as a coating on quartz. Under the microscope the scales are found to be hexagonal plates with rhombohedral planes on the edges. Notwithstanding the minuteness of the crystals it was found possible to measure them, and so to determine the length of the vertical axis, namely, $c = 1.1389$. The mineral has been analyzed by M. Damour and shown to correspond with the formula $3\ Fe_2O_3,\ 3\ SO_3 + 4\ H_2O$; it is consequently a basic sulphate of iron sesquioxide. (*Zeitsch. Kryst.*, IX, 558; or *Bull. Soc. Min. France*, VII, 126, 128.)

Xanthoarsenite.—Described by Igelström as a new arsenate of manganese from the Sjö mines in the parish of Grythyttan, Sweden. It occurs in sulphur-yellow masses, resembling the yellow compact garnet found with rhodonite at the Långban mines. It is associated with hausmannite, magnetite, and hematite. No crystals were found, but Bertrand has shown that it is optically biaxial; whether it belongs to the orthorhombic, monoclinic, or triclinic system could not be decided. An analysis showed it to be a hydrous arsenate of manganese chiefly, with also a little antimony replacing the arsenic, and small quantities of iron, magnesium, and calcium replacing the manganese. It is very near the chondroarsenite of the same author, only differing in containing a little more water, and having a more decidedly yellow color; it is also related to the manganese arsenates from Nordmark described above. (*Bull. Soc. Min.*, VII, 237.)

Zunyite.—A remarkable new mineral described by Hillebrand from the Zuñi mine on Anvil Mountain, near Silverton, San Juan County, Colorado. It occurs intimately intermingled with the sulphide of arsenic and lead, guitermanite (see above), from which it was separated for examination by removing the sulphide by nitric acid. The crystals

thus obtained were found to be tetrahedral in habit, with also the planes of the minus tetrahedron, cube, and perhaps the dodecahedron; there is cleavage parallel to the faces of both tetrahdrons. The crystals are clear and transparent, except as rendered black and opaque by inclusions of black grains of titanic oxide. The luster is vitreous. The hardness is about 7, and the specific gravity 2.875. Several careful analyses were made which fix in general the composition of the mineral, but without entirely establishing its exact formula. It is shown to be a silicate of aluminum, very low in silica, with nearly 11 per cent. of water assumed to be basic, as it does not go off at 270°C., also 5.6 per cent. fluorine and 3 per cent. chlorine. The mineral is then as remarkable in composition as in crystalline form, and deserves further study. (*Proc. Colorado Scientific Soc.*, vol. I, 124.)

NECROLOGY OF MINERALOGISTS, 1884.

FRIEDRICH KLOCKE.—Born May 28, 1847, in Breslau; died June 17, 1884. He was assistant in mineralogy at Heidelberg in 1868–'70; in 1879 he became "ausserordentlicher Professor" at Freiburg, in Breisgau; in 1881 he became "ordentlicher Professor" of mineralogy and petrography at Marburg. The list of his scientific papers includes 17 articles, many of them devoted to physical mineralogy; his most important contributions are those upon the cause of "optical anomalies" of crystals as due to secondary causes. (See the Reports for 1882, 1883.)

JOHANNES LORENZEN.—Born November 23, 1855, in Sönder-Jylland; died May 5, 1884, when on his way from Copenhagen to Greenland. He was curator of the Mineralogical Museum at Copenhagen, and the author of a number of important mineralogical papers. Among his contributions may be mentioned his memoirs on the metallic iron of Greenland, and the minerals occurring in the sodalite-synite of the Tunngdliarfik and Kangerdluarsuk fiords of Southern Greenland.

QUINTINO SELLA.—Born at Mosso, in Piedmont, July 17, 1827; died March 14, 1884. He was a mathematician and mineralogist of the highest rank, and at the same time one of the foremost statesmen of United Italy. In the last capacity he served in several distinguished positions, being for many years minister of finance. His scientific contributions were chiefly in crystallography; he also took an active part in the arrangements with reference to the geological survey of Italy. He was president of the R. Accademia dei Lincei.

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BAUMHAUER, H. Kurzes Lehrbuch der Mineralogie. 190 pp. 8vo. Freiburg, Baden.

BOURGEOIS, L. Reproduction artificielle des minéraux. 288 pp. 8vo. Paris, 1884. (Encyclopédie Chimique.)

BREZINA, A. Krystallographische Untersuchungen an homologen und isomeren Reihen. Eine von der kais. Akademie der Wissenschaften in Wien mit dem Freiherrn von Baumgartner'schen Preise gekrönte, durch einen methodologischen Theil vermehrte Schrift. 1. Theil. Methoden. 359 pp. 8vo. Vienna, 1884.

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HANKS, H. G. Third Annual Report of the State Mineralogist of California for the year ending June 1, 1883. 111 pp. 8vo. Sacramento, 1883.

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KOBELL, F. VON. Tafeln zur Bestimmung der Mineralien, etc. 12. neu bearbeitete und vermehrte Auflage von K. Oebbecke. Munich, 1884.

KOKSCHAROW, N. VON. Materialien zur Mineralogie Russlands. Vol. ix, pp. 1–80. St. Petersburg, 1884.

LANDERO, CARLOS F. DE. Informe sobre las especies minerales des Estado de Jalisco. 41 pp. 8vo. Guadalajara, 1884.

MALLARD, E. Traité de Cristallographie géométrique et physique. Tome second. Cristallographie physique, avec 184 figures et 8 planches tirées en couleur. 599 pp. 8vo. Paris, 1884. (Tome premier, 1879.)

MEUNIER, STANISLAS. Météorites. 532 pp. 8 vo. Paris, 1884. Encyclopédie chimique. Tome II. Métalloïdes. Appendice, 2me cahier.

PHILLIPS, J. ARTHUR. A treatise on ore deposits. 652 pp. 8vo. London, 1884.

SMITH, J. LAWRENCE. Original researches in mineralogy and chemistry, edited by J. B. Marvin. 630 pp. 8 vo. Louisville, Ky.

TSCHERMAK. Die mikroskopische Beschaffenheit der Meteoriten erläutert durch photographische Abbildungen. Die Aufnahmen von J. Grimm in Offenburg. Lief. 2.

WEISBACH, A. Synopsis mineralogica. Systematische Uebersicht des Mineralreiches. 87 pp. 8vo. 1884.

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BECKE, F. Aetzversuche am Bleiglanz. Min. Petr. Mitth., VI, 237.

BLOMSTRAND, C. W. Om ett uranmineral från trakten af Moss samt om de nativa uranaterna i allmänhet. Geol. För.. Förh. Stockholm, VII, 59.

CROSS, W. A list of specially noteworthy minerals in Colorado. Proc. Colorado Sci. Soc., I, 134–144.

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DOELTER and HUSSAK. Ueber die Einwirkung geschmolzener Magmen auf verschiedene Mineralien. Jahrb. Min., 1884, I, 18.

——— Synthetische Studien. *ib.*, p. 158.

DUFET, H. Influence de la température sur les indices de réfraction du quartz. Bull. Soc. Min. France, VII, 182.

FÖRSTNER, H. Ueber künstliche physikalische Veränderungen der Feldspäthe von Pantelleria. Zeitsch. Kryst., IX, 333.

GRÜNHUT, L. Beiträge zur krystallographischen Kenntniss des Andalusites und des Topazes. Zeitsch. Kryst., IX, 113.

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* In this list are given the full titles of the more important mineralogical memoirs of the past year, especially those of a general and theoretical character. Many others are referred to in the preceding pages.

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——— Beiträge zur Kenntniss des Boracit. Jahrb. Min., 1884, I, 235.

KLEIN, W. Beiträge zur Kenntniss der optischen Aenderungen in Krystallen unter dem Einflusse der Erwärmung. Zeitsch. Kryst., IX, 38.

KLOOS, J. H. Beobachtungen an Orthoklas und Mikroklin. Jahrb. Min., 1884, II, 87.

KOLENKO, B. VON. Die Pyroelektricität des Quarzes in Bezug auf sein krystallographisches System. Zeitsch. Kryst., IX, 1.

KROUSTCHOFF, K. DE. Sur l'analyse spectrale appliquée aux études microminéralogiques. Bull. Soc. Min. France, VII, 243.

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LORENZEN, J. Untersuchungen einiger Mineralien aus Kangerdluarsuk. Zeitsch, Kryst., IX, 243.

——— A chemical examination of Greenland telluric iron. Min. Mag., VI, 14.

MACK, K. Ueber das pyroelectrische Verhalten des Boracits. Wied. Ann., XXI, 410.

MALLARD, E. Sur l'isomorphisme des chlorates et des azotates, et sur la quasi-identité vraisemblable de l'arrangement moléculaire dans toutes les substances cristallisées. Bull. Soc. Min. France, VII, 349–401.

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MERIAN, A. Studien an gesteinsbildenden Pyroxenen. Jahrb. Min., Beilage-Bd., III, 252.

MICHEL-LÉVY, A. Note sur la biréfringence de quelques minéraux; application à l'étude des roches en plaques minces. Bull. Soc. Min. France, VII, 43.

MIERS, H. A. The crystallography of bournonite. Min. Mag., VI, 59; Meneghinite *ib.*, V, 325.

MINNEGERODE, B. Ueber die Symmetrie-Verhältnisse und die Elasticität der Krystalle. Nachr. k. Ges. Wiss., Göttingen, pp. 374–384; pp. 488–492.

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——— Ueber Schlagfiguren und künstliche Zwillingsbildung am Leadhillit, und die Dimorphie dieser Substanz. *Ib.*, p. 63.

——— Bemerkungen über die Zwillingsbildung einiger Mineralien. *Ib.*, p. 216.

RAMMELSBERG, C. F. Ueber isomorphe, chemisch nicht analoge Mineralien. Jahrb. Min., 1884, II, p. 67.

——— Ueber den Boronatrocalcite und die natürlichen Borate überhaupt. *Ib.*, p. 158.

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——— Ueber die Trimorphie und die Ausdehnungs-Coefficienten von Titandioxid. *Ib.*, p. 433.

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SJÖGREN, A. Mineralogiska Notiser, VII. Geol. För. Förh., Stockholm, VII, 109; VIII, *ib.*, p. 177.

SJÖGREN, HJ. Kristallografiska Studier, VII. Geol. För. Förh., Stockholm, VII, 124; VIII, *ib.*, p. 220; IX–XI, *ib.*, p. 369.

SJÖGREN, HJ. Om manganarseniaternas från Nordmarken förekomstsätt och paragenesis. Ib., p. 407.

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STEENSTRUP, K. J. V. On the existence of nickel-iron with Widmannstätten figures in the basalt of North Greenland. Min. Mag., VI, 1.

THOULET, J. Mesure du coefficient de dilatation cubique des minéraux. Bull. Soc. Min. France, VII, 151.

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VOIGT, W. Zur Theorie der Absorption des Lichtes in Krystallen. Nachr. k. Ges. Wiss. Göttingen, pp. 137 and pp. 337–363. Wied. Ann., XXIII, 577.

WEBSKY, M. Ueber die Ein- und Mehrdeutigkeit der Fundamental-Bogen-Complexe für die Elemente monoklinischer Krystall-Gattungen. Sitzber. k. Preuss. Akad. Wiss., Berlin, April 17, 1884.

A REVIEW OF THE PROGRESS OF NORTH AMERICAN INVERTEBRATE PALÆONTOLOGY FOR 1884.

By JOHN BELKNAP MARCOU.

In this work I have endeavored to collect the titles of all of the works on North American invertebrate palæontology published during the past year. An attempt has been made to give a brief idea of the contents of each work, the new genera and species described, and the general conclusions of the authors. The alphabetical arrangement by authors seemed, after a good deal of thought, the best method of arrangement and has consequently been adopted. The explanatory notices are placed after each title. The work I hope will prove useful, and I will be glad if those who notice them will call my attention to any omissions.

AMI, H. M.—Notes on *Triarthus spinosus* Billings. (Trans. Ottawa Field Naturalists' Club, No. 4. Ottawa, 1883.)

Interesting notes on this Trilobite with two figures, one a copy of Billings's, the other original, with some of the furrows and grooves on the occipital segment imperfectly figured.

BEECHER, C. E.—*Ceratiocaridæ* from the Chemung and Waverly Groups at Warren, Pa. (Rep. of progress, P. P. P., 2d Geol. Surv. Penna., pp. 1–22, pls. i and ii, Harrisburg, 1884.)

A very interesting paper on a group of which but little is known. Gives descriptions of two new genera, *Elymocaris* and *Tropidocaris*, *El. siliqua* n. sp. and *T. bicarinata*, *T. interrupta*, *T. alternata* n. sp., and also a new species of *Echinocaris*, *E. socialis* n. sp. He also redescribes and gives good figures of *E. punctata* Hall. The figures and descriptions are excellent; a short bibliography of the subject is also given.

BILLINGS, W. R.—Notes on, and description of, some fossils from the Trenton Limestone. (Trans. Ottawa Field Naturalists' Club, No. 4. Ottawa, 1883.)

Describes a new species, *Heterocrinus bellevillensis*, with good figures. Gives a good illustration showing the arms of *Dendrocrinus jewettii* Billings, 1859; he estimates their number at least at forty. Describes

a new variety of *Amygdalocystites florealis* as var. *lævis*. The illustrations are good. He records the existence in the Trenton limestone at Brigham's Lake, Hull, of *Iocrinus subcrassus*, *Glyptocrinus decadactylus*, and *Gl. parvus*.

CHAPMAN, E. J.—A Classification of Crinoids. (Trans. Royal Soc. Canada, vol. I, section iv, 1882, pp. 113–116. Montreal, 1883.) [Appeared 1884.]

This classification is based on the presence or absence of a canaliculated structure in the calyx and arm-plates. The author makes three divisions with a subdivision in the first and second divisions. In the first division the plates (apart from the stem segments) are without internal canals; in the second the arm-plates are perforated internally; and in the third a system of canals radiates from the base of the calyx to the extremities of the arms. The following is a summary of the classification:

I. Emedullata:
- 1. Amplicincta:
  - 1. Proclinata (*e. g.* Cheirocrinus).
  - 2. Attenuata (*e. g.* Pisocrinus; Hybocrinus).
  - 3. Spatiosa (*e. g.* Platycrinus).
  - 4. Pinnigera (*e. g.* Poteriocrinus).
  - 5. Disjuncta (*e. g.* Marsupites).
- 2. Multicincta:
  - 1. Squamosa (*e. g.* Ichthyocrinus).
  - 2. Copulata (*e. g.* Melocrinus; Eucalyptocrinus).
  - 3. Ornata (*e. g.* Actinocrinus; Glyptocrinus).
  - 4. Opulenta (*e. g.* Polypeltes).
  - 5. Mutica (*e. g.* Uintacrinus).

II. Fistulata:
- 1. Ramosa (*e. g.* Cyathocrinus)
- 2. Foliata (*e. g.* Crotalocrinus).
- 3. Fimbriata (*e. g.* Cupressocrinus).
- 4. Quadrata (*e. g.* Gasterocoma).

III. Canaliculata:
- 1. Crassicincta:
  - 1. Frondosa (*e. g.* Pentacrinus).
  - 2. Vagata (*e. g.* Antedon).
  - 3. Florifera (*e. g.* Encrinus).
  - 4. Coadunata (*e. g.* Eugeniacrinus).
  - 5. Conformata (*e. g.* Apiocrinus; Bourgetticrinus; Rhizocrinus).
- 2. Tenuicincta:
  - 1. Carinata (*e. g.* Hyocrinus).
  - 2. Truncata (*e. g.* Holopus).

CLAYPOLE, E. W.—On the occurrence of the Genus *Dalmanites* in the Lower Carboniferous Rocks of Ohio. (Geol. Magazine, 3d Decade, July, 1884, vol. i, No. vii, pp. 303, 307, London.)

The author describes *Dalmanites? Cuyahogæ*, illustrated by a woodcut, and he discusses the Trilobitic fauna of the carboniferous.

DWIGHT, WILLIAM B.—Recent Explorations in the Wappinger Valley Limestone of Dutchess County, New York, No. 4.

Descriptions of Calciferous ? Fossils. (Amer. Journ. of Sci. and Arts, April, 1884, vol. XXVII, article xxix, pp. 249–259, pl. vii, New Haven, 1884.)

The figures are clear. The new species described are as follows: *Bathyurus taurifrons*, *B. ? crotalifrons*, *Cyrtoceras vassarina*, *C. ? dactyloides*, *C. microscopicum*, *Orthoceras spissiseptum*, *O. Henrietta*, and *Oncoceras vasiforme*.

FOERSTE, AUG. F.—The Power of Motion in Crinoid Stems (January. 1884). (Amer. Naturalist, vol. XVIII, No. 1, pp. 57, 58; figure in text, Philadelphia, 1884.)

The author, from the fact that he found a crinoid stem disposed in a perfect natural coil, argues that it placed itself in that position, was destroyed while in that position, and must have had the power of motion to place itself in that position.

FONTAINE, W. M.—Contributions to the Knowledge of the older Mesozoic Flora of Virginia. Monographs of the United States Geological Survey, vol. VI, pp. 1–144, pls. i–liv. 4to. Washington, 1883. [Appeared December, 1884.]

This work is divided into three parts. In the first Professor Fontaine gives a brief description of the geology of the Virginia Mesozoic areas. In the second he describes the flora, among it the two new genera, *Mertensides* n. g. and *Pseudodanæopsis* n. g., and twenty-seven new species: *Schizoneura virginiensis*, *Acrostichides rhombifolius*, *A. microphyllus*, *A. densifolius*. *Mertensides distans*, *Asterocarpus virginiensis*, *A. platyrachis*, *A. penticarpa*, *Pecopteris rarinervis*, *Cladophlebis subfalcata*, *C. auriculata*, *C. ovata*, *C. microphylla*, *C. pseudowhitbiensis*, *C. rotundiloba*, *Lonchopteris virginiensis*, *Pseudodanæopsis reticulata*, *P. nervosa*, *Petrophyllum inæquale*, *Ctenophyllum truncatum*, *C. grandifolium*, *C. giganteum*, *Podozamites emmonsi*, *Sphenozamites rogersianus*, *Cycadites tenuinervis*, *Zamiostrobus virginiensis*, *Baiera multifida*.

A table comparing them with plants from the Triassac, Jurassic, and Rhætic of other regions is given; 9 per cent. show affinities with Triassic forms, 19 per cent. with Jurassic forms, and 28 per cent. with Rhætic forms. The flora must therefore be considered not older than the Rhætic.

In the third part he republishes Emmons's figures of the Mesozoic flora

of North Carolina and compares this flora with that of Virginia in a table, showing also the affinities to Jurassic, Rhætic, and Triassic plants of foreign countries. This list contains thirty-nine species. Twenty-three per cent. of these are peculiar to North Carolina, 41 per cent. are found in Virginia, 20 per cent. are allied to or identical with Jurassic forms, and 38 per cent. are allied to or identical with Rhætic forms, and therefore the North Carolina flora may be considered of the same age as that of Virginia.

FORD, S. W.—Note on the Discovery of Primordial Fossils in the Town of Stuyvesant, Columbia County, New York. (Amer. Jour. Sci. and Arts, July, 1884, art. vi, vol. XXVIII, pp. 35–37.)

Mr. Ford considers that the 120 feet of strata he finds in Columbia County are simply a southern prolongation of the Troy primordial series.

HALL, JAMES.—Notes on the Family *Dictyospongidæ*. Observations on the Genera *Cyathophycus*, *Dictyophyton*, *Phragmodictya*, *Clathrospongia*, *Physospongia*, and their relations to *Uphantænia*. (35th Report of the New York State Museum Nat. Hist., pls. xvii–xx.)

Plates published in advance; one hundred copies have been distributed.

HALL, JAMES.—Descriptions of the Species of Fossil Reticulate Sponges. constituting the Family *Dictyospongidæ*, pp. 1–19. Albany, 1884. (Abstract of a paper to be issued in the 35th Museum Report.)

Contains further description of the forms indicated in the previous title. The new genera *Ectenodictya*, *Lyrodictya*, *Thamnodictya*, *Phragmodictya*, *Cleodictya*, and *Physospongia*, are characterized, and the following new species are described: *Dictyophyton hamiltonense*, *D. patulum*, *D. prismaticum*, *D. telum*, *D. irregulare*, *D. baculum*, *D. paralellum*, *D. cinctum*, *D. sacculum*, *Ectenodictya burlingtonensis*, *Lyrodictya romingeri*, *Phragmodictya patelliformis*, *Cleodictya gloriosa*, *C. ? mohri*, *Physospongia colletti*.

HALL, JAMES.—Palæontology. Vol. v, part 1. Lamellibranchiata I. Text and plates. Containing descriptions and figures of the Monomyaria of the Upper Helderberg, Hamilton, and Chemung Groups. (Geological Survey of the State of New York, pp. i–xviii and 1–268. Explanation of plates i–xxxiii and lxxxi–xcii. Albany, 1884.)

Plates i–xxxiii were published last year in advance; plates lxxxi to xcii have not yet appeared, and no plates at all are bound in the volume. Another volume will appear next year containing the descriptions of the remainder of the forms illustrated on plates xxxiv–lxxx, inclusive. In this the author proposes to give a *résumé* of all the genera described, and, in the same connection, a comparison with genera described in other publications, with some notice of the bibliography of this class of fossils

so far as relates to the palæozoic forms. In that notice the reasons for the generic subdivisions used in the present volume will be given in full.

The following new genera are proposed in this volume: *Crenipecten*, *Lyriopecten*, *Pterinopecten*, *Actinopteria*, *Ptychopteria*, *Limoptera*, *Glyptodesma*, *Leiopteria*, *Leptodesma*, *Palæopinna*, *Ectenodesma*, *Byssopteria*, and three subgenera, *Plethomytilus* a s. g. of *Mytilarca* Hall, *Mytilops* a s. g. of *Modiola*, and *Vertumnia* a s. g. of *Pterinea*. All these are republished, except *Vertumnia*, with but few modifications from the few pages of text preceding the volume of plates published the year previous.

The following new species are described: *Aviculopecten æquilateralis*, *Pterinopecten reflexus*, *P. nodosus*, *P. lætus*, *P. intermedius*, *P. regularis*, *P. dispandus*, *Pterinea grandis*, *Pterinea interstrialis*, *P.* (*Vertumnia*) *reproba*, *Actinopteria doris*, *A. pusilla*, *A. tenuistriata*, *A. auriculata*, *A. eta*, *A. theta*, *A. iota*, *A. kappa*, *Ptychopteria thetis*, *P. falcata*, *P. spio*, *P. eudora*, *P. trigonalis*, *P. elongata*, *P. galene*, *P. beecheri*, *P. spatulata*, *P. lata*, *P. perlata*, *P. thalia*, *P. gibbosa*, *P. lobata*, *P. vanuxemi*, *Leiopteira sayi*, *L. troosti*, *L. leai*, *L. gabbi*, *L. linguiformis*, *L. torreyi*, *Leptodesma shumardi*, *Leptodesma agassizi*, *L. billingsi*, *L. stephani*, *L. medon*, *L. cadmus*, *L. creon*, *L. demus*, *L. loxias*, *L. mentor*, *L. hector*, *L. clitus*, *L. truncatum*, *L. corydon*, *L. jason*, *L. pelops*, *L. orcus*, *L. nereus*, *L. alatum*, *L. orus*, *L. biton*, *L. lesleyi*, *L. aviforme*, *L. flaccidum*, *L. patulum*, *L. arciforme*, *L. phaon*, *L. propinquum*, *L. quadratum*, *L. acutirostrum*, *Pteronites inoptatus*, *Mytilarca* (*Plethomytilus*) *knappi*, *Mytilarca regularis*, *M. gibbosa*.

HAMBACH, G.—Notes about the Structure and Classification of the Pentremites. (Trans. Acad. Sci. Saint Louis, vol. IV, No. 3, pp. 537–547. Saint Louis, 1884.)

A portion of the paper is devoted to answering Mr. Carpenter's criticisms on the author's paper on the Anatomy of the Blastoidea. The author considers *Pentremites* more closely related to *Echinus* than to the Crinoidea; he considers it impracticable to divide the genus *Pentremites* into four or five new genera, as has been proposed by Mr. Carpenter. Mr. Hambach thinks that all described *Pentremites* (except those which belong to the genus Codaster or Codonites) can easily be distributed in one of these three divisions, viz: First division comprises all species in which the horizontal portion of the deltoid piece is very narrow, the sinus to both sides in the deltoid and lancet pieces comparatively large, and so surrounded by the zigzag plicated integument that two of the so formed openings appear externally only as one, *e. g.*, *P. florealis* Say, and *P. reinwardtii* Troost. The second division comprises all species in which the deltoid pieces are very broad, the lancet pieces very narrow, and the sinus for the formation of the spiracle openings in both deltoid and lancet pieces very little; the zigzag plicated integument corresponding to the narrow ambulacral field is not wide enough to surround these openings fully, hence they have to remain

separate, or, in other words, where we have ten distinctly visible openings, *e. g.*, *P. mels* Owen & Shumard, and *P. crenulatus* Roemer. The third division comprises all species in which the deltoid pieces are perforated, because the lancet pieces do not reach far enough to the summit to enter into the composition of the spiracle openings, *e. g.*, *P. norwoodi* Owen & Shumard, and *P. ellipticus* Sowerby. The article is illustrated by six figures in the text.

HAMBACH, G.—Description of new Palæozoic Echinodermata. (Trans. Acad. Sci. Saint Louis, vol. IV, No. 3, pp. 548–554, pls. C and D. Saint Louis, 1884.)

The author describes the following new species from the subcarboniferous limestones: *Melonites crassus*, *M. irregularis*, *Oligoporus parvus*, *Archæocidaris newberryi*, *Pentremites sampsoni*, *P. gemmiformis*, *Codonites campanulatus*.

HEILPRIN, ANGELO.—North American Tertiary Ostreidæ. Appendix I. (White, C. A. A Review of the Fossil Ostreidæ of North America.)

N. B.—See Dr. C. A. White's work.

HEILPRIN, ANGELO.—On a Carboniferous Ammonite from Texas. (Proc. Acad. Nat. Sci. Philadelphia, 1884, pp. 53–55, figs. 1 and 2, p. 53.)

Describes *Ammonites Parkeri*, considers it closely related to "*Arcestes antiquus*" Waagen. It is associated with *Zaphrentis*, *Phillipsia*, *Bellerophon*, *Conularia*, *Chonetes*, and *Productus*. Professor Heilprin refers this form to the "old genus *Ammonites*," but as nearly as can be judged from the figures and descriptions we would place it in the genus *Popanoceras* Hyatt, of which *Arcestes antiquum* Waagen is an extreme form.

HEILPRIN, ANGELO.—Contributions to the Tertiary Geology and Palæontology of the United States. Pp. 1–117. 4to. Philadelphia, 1884.

This paper contains discussions of the various Tertiary formations of the United States, lists of fossils occurring therein, and a comparison of some American and European forms, most of which have already been published in substance in the Proc. of the Acad. Nat Sci. of Philadelphia. It is to be regretted that the book is not provided with an index, and that Mr. Heilprin has not given the names of the authors when citing species and giving lists of them.

HYATT, ALPHEUS.—Evolution of the Cephalopoda. (Science, vol. III, Nos. 52 and 53, pp. 122–127 and 145–149. Cambridge, 1884.)

An illustrated article containing in a condensed form Professor Hyatt's views on the subject.

HYATT, ALPHEUS.—The Protoconch of Cephalopoda. (Amer. Naturalist, vol. XVIII, No. 9, pp. 919, 920. Philadelphia, 1884.)

Mr. Hyatt says that his observations establish the fact that in the

Nautiloidea the bulb is covered by a true protoconch continuous with the shell of the apex.

HYATT, ALPHEUS.—Genera of Fossil Cephalopods. (Proc. Boston Soc. Nat. Hist., April 4, 1883, vol. XXII, pp. 253–338. Boston, 1884.)

This paper is preliminary to a monograph which will appear in the memoirs of the Museum of Comp. Zoology. The first dozen pages are devoted to a discussion of the Cephalopoda. The rest of the article is a description of genera arranged according to the author's system of classification and based on his studies of the development of the Cephalopoda. The following new genera are established: *Vaginoceras*, *Plectoceras*, *Litoceras*, *Diadiploceras*, *Metacoceras*, *Tainoceras*, *Mojsvaroceras*, *Grypoceras*, *Enclimatoceras*, *Sactoceras*, *Geisonoceras*, *Cycloceras*, *Kionoceras*, *Spyroceras*, *Dawsonoceras*, *Rizosceras*, *Acleistoceras*, *Tetrameroceras*, *Hexameroceras*, *Trimeroceras*, *Pentameroceras*, *Septameroceras*, *Billingsites*, *Mœlonoceras*, *Oonoceras*, *Cranoceras*, *Nœdyceras*, *Eremoceras*, *Ptyssoceras*, *Anomaloceras*, *Centroceras*, *Zittelloceras*, *Halloceras*, *Rutoceras*, *Triplooceras*, *Kophinoceras*, *Strophiceras*, *Solenoceras*, *Phloioceras*, *Tripteroceras*, *Edaphoceras*, *Tripleuroceras*, *Apsidoceras*, *Titanoceras*, *Ephippioceras*, *Stroboceras*, *Discitoceras*, *Phacoceras*, *Aphelæceras*, *Triboloceras*, *Koninckioceras*, *Aipoceras*, *Sphyradoceras*, *Uranoceras*, *Barrandeoceras*, *Pselioceras*, *Nephriticeras*, *Cenoceras*, *Cymatoceras*, *Mimoceras*, *Heminautilinus*, *Celæceras*, *Gephuroceras*, *Manticoceras*, *Parodiceras*, *Tornoceras*, *Mœneceras*, *Sporadoceras*, *Brancoceras*, *Munsteroceras*, *Gastrioceras*, *Paralegoceras*, *Prinoceras*, *Glyphioceras*, *Dimeroceras*, *Homoceras*, *Nomismoceras*, *Dimorphoceras*, *Sandbergeoceras*, *Beloceras*, *Pharciceras*, *Schistoceras*, *Triainoceras*, *Popanoceras*.

HYATT, ALPHEUS.—Fossil Cephalopoda in the Musuem of Comparative Zoology. (Proc. of the Amer. Ass. for theAdv. of Sci., vol. XXXII, pp. 323–361, Minneapolis meeting, August, 1883.) [Not distributed till 1884.]

This is also a partial abstract from the monograph just mentioned, and a very interesting discussion of the classification and evolution of this group.

JAMES, J. F.—Two Species of Tertiary Plants. (Science, vol. III, No. 62, p. 433. Cambridge, 1884.)

Mr. James criticises two of the determinations made by Professor Lesquereux in his Tertiary Flora (U. S. Geol. and Geogr. Surv. Terr., F. V. Hayden in charge.) [Not yet published.]

JAMES, J. F.—The Fucoids of the Cincinnati Group. (Jour. Cincinnati Soc. Nat. Hist., October, 1884, vol. VII, pp. 1–9, pls. v and vi.)

The author is a little premature in condemning to the rank of mud bubbles some of the Silurian fossils. A little inquiry would have elicited

the fact that sponge spicules have been found in *Cyathophycus subsphæricus* Walcott, which he degrades to the rank of a mud bubble.

JAMES, U. P.—Description of Three Species of Fossils. (Jour. Cincinnati Soc. Nat. Hist., April, 1884, vol. VII, pp. 1–4.)

Decribes *Stromatopora subcylindrica*, *Fistilupora oweni*, *Cerampora ? beani*, illustrated by cuts in the text. They occur in the Cincinnati Group.

JAMES, U. P.—Description of Four New Species of Fossils from the Cincinnati Group. (Jour. Cincinnati Soc. Nat. Hist., October, 1884, vol. VII, pp. 137–140, pl. vii.)

Describes *Monticulipora ohioensis*, *M. falesi*, *Stromatopora tubularis*, and *S. ludlowensis*.

JAMES, U. P.—On Conodonts and Fossil Annelid Jaws. (Jour. Cincinnati Soc. Nat. Hist., October, 1884, vol. VII, pp. 143–149, pl. vii.)

Mr. James concludes that the weight of evidence favors the view that *Conodonts* are the jaws and lingual teeth of Mollusks. He describes two new species of *Conodonts*, *Prioniodus Dychei* and *Polygnathus Wilsoni*, and also two new species of Annelids, *Arrabellites aciculatus* and *A. hindei*.

JONES, T. R., and J. W. KIRKBY.—On some Carboniferous Entomostraca from Nova Scotia. (Geol. Magazine, 3d Decade, August, 1884; vol. I, No. viii, pp. 356–362, pl. xii. London.)

Describes and makes notes on about ten species and varieties, of which two are new, *Beyrichia nova scotia*, and *Candona ? elongata*.

JONES, T. R., and H. WOODWARD.—Notes on Phyllopodiform crustaceans, referable to the genus Echinocaris, from the Palæozoic Rocks. (Geol. Mag., Decade iii, vol. I, pp. 1–4, pl. xiii. London, 1884.)

Echinocaris wrightiana Dawson sp. The fossils discussed in this paper are from New York State.

LESQUEREUX, LEO.—Description of the Coal Flora of the Carboniferous Formation in Pennsylvania and throughout the United States. (Second Geol. Surv. Pennsylvania, Rep. Progress P, vol. III, pp. 695–977, pls. 88–111. Harrisburg, Pa., 1884.)

This third and last volume contains besides new matter, additions and corrections to the first and second volumes (published in 1880)

It contains a table of species referred to localities, a table of species referred to formations, and a revised index of generic and specific names referred both to pages and to plates for all three volumes. This volume contains twenty-six good lithographic plates; the pagination of the three volumes is continuous, making a total of 977 pages and 111 plates. The author has endeavored to find out if, as it has been surmised by European authors, it would be possible to recognize, by the presence

of certain species of plants, the divers horizons of coal strata in different localities. But with the exception of a few cases of marked identity, as long as the observations were confined to a field of limited area, he considers it is right to say that generally the data furnished by remains of fossil plants are either insufficient or deceptive; insufficient, because the specimens of fossil plants are rarely found representing such a number of species that a satisfactory comparison can be made between the plants of different localities; deceptive, because the vegetation of the coal period, like that of the present epoch, has been subjected to great variations, according to geographical distribution or local influences. Professor Lesquereux makes four distinct modifications of the essential characters of the pre-Carboniferous and Carboniferous floras. The first, comprising the Lower or pre-Carboniferous, is persistent in the Devonian, Chemung, and the Catskill; the second, partly marked in the Pocono, becomes modified and persistent in the sub and intra conglomerate measures; the third pertains to the lower productive coal measures from above the conglomerate to the base of the barren beds of Pennsylvania; the fourth is that of the upper productive coal measures, including the Pittsburgh coal and a few hundred feet above. Of course some species of each group have a greater degree of persistence, and pass from a lower to an upper stage.

The author describes the new genus *Dendrophycus* and the following new species:

Dendrophycus desorii, Calamostachys lanceolata, C. brevifolia, Volkmannia crassa, V. fertilis, Annularia cuspidata, Equisetites gracilis, Neuropteris carrii, N. oblongifolia, N. blissii, N. Griffithii, Odontopteris patens, O. monstruosa, O. affinis, Tæniopteris truncata, Megalopteris rectinervis, Callipteridium rigidum, Alethopteris crassa, Pseudopecopteris hispida, Pecopteris carrii, Pecopteris georgiana, Pecopteris ornata, Sphenopteris communis, S. inæquilateralis, S. harveyi, S. (Diplothmema) tracyana, S. royi, S. solida, Eremopteris cheathami, Archæopteris denticulata, A. sphenophyllifolia, A. macilenta, Lycopodites arborescens, L. flexifolius, L. lacoei, Lepidophloios dilatatus, Lepidophyllum cultriforme, L. fallax, L. campbellianum, L. gracile, L. minutum, L. coriaceum, L. elegans, Tæniophyllum brevifolium, Sigillaria Grand 'Euryi, S. leverethii, Cordaianthus flexuosus, C. spicatus, C. rugosus, Cordaicarpus cinctus, Cordaicarpus stabilis, C. lineatus, Cardiocarpus dilatatus, Cardiocarpus patens, C. speciosus, C. Harveyi, C. longicollis, C. ovalis, C. conglobatus, C. divergens, C. latior, C. crassus, C. circularis, C. diplotesta, C. pusillus, Rhabdocarpus late-costatus, R. inflatus, R. sub-globosus, R. pachytesta, R. emarginatus, R. tenax, R. abnormalis, R. apiculatus, Trigonocarpus adamsii, T. perpusillus, Trigonocarpus grandis, T. starkianus, T. kansaseanus, T. multistriatus, T. ampullæformis, Carpolithes conicus, C. butlerianus, C. perpusillus, C. latior, C. transectus, Dictyophytum ramosum, Macrostachya communis, M. minor, Odontopteris dilatata, Lesleya microphylla, Megalopteris dentata, M. serrata, Alethopteris evansii, A. robusta, Stemmatopteris microstigma, S. anceps?, Rachiopteris squamosa, Lepidodendron rigidum, Knorria com-

pacta, *Lepidostrobus butleri*, *L. latus*, *Lepidophyllum stantoni*, *Whittleseya microphylla*, *Cordaianthus scaber*, *C. ebracteatus*.

LESQUEREUX, LEO.—Principles of Paleozoic Botany. (Indiana department of Geology and Natural History, 13th Ann. Rep., Part ii, Palæontology, pp. 7–106, pls. i–xxi, John Collett, State geologist, 1883. Indianapolis, 1884.)

In the descriptive part of this work Mr. Lesquereux gives descriptions of the coal flora, a part of which are modified or borrowed from his U. S. Coal Flora, Report P, of the 2d Geol. Surv. Penna. The plates and figures are very good of their kind, and the whole work answers very well its purpose of an elementary treatise on the subject. The Geological Survey of Indiana has done excellent work in this direction. and it is to be hoped that its labors will not be permanently discontinued.

LESQUEREUX, LEO.—The Carboniferous Flora of Rhode Island. (Amer. Naturalist, No. 9, September, vol. XVIII, pp. 921–923. Philadelphia, 1884.)

The author gives a list of eighty-eight species, of which fifty-six are ferns, and describes two new species, *Sphenopteris fuciformis* and *Callipteridium* sp. n. ?, or variety of *Alethopteris urophylla* Brgt.

MARCOU, J. B.—A Review of the Progress of North American Invertebrate Palæontology for 1883. (Amer. Naturalist, April, vol. XV, No. 4, pp. 385–392. Philadelphia, 1884.)

MATHEW, G. F.—The Primitive Conocoryphean. (Geol. Mag. 3d Decade, vol. I, pp. 471, 472, 1884. London, 1884.)

Relates to the development of the species *Ctenocephalus Mathewi* and other Conocorypheans of the Acadian fauna, and is considered under the three heads, development of the Glabella, acquisition of sensory organs, and the decoration of the test.

MATHEW, G. F.—The Geological Age of the Acadian Fauna. (Geol. Mag. 3d Decade, vol. I, pp. 470, 471. London, 1884.)

An attempt is made to show more accurately than has yet been done the position of the Saint John Cambrian. It is shown that the genera and species of the Acadian trilobites do not agree with those of the Menevian in its more restricted sense. Mr. C. D. Walcott considers the Saint John fauna as the oldest known Cambrian fauna. Both the above papers are apparently abstracts of papers prepared for the meeting of the British Association for the Advancement of Science, at Montreal, in 1884.

MATHEW, G. F.—Illustrations of the Fauna of the Saint John Group, No. 1. The Paradoxides. (Trans. Roy. Soc. Canada, section iv, 1882, pp. 87–108, pl. ix, 1883. Montreal, 1884.)

Contains a brief history of the discovery and study of the Saint John group, an account of the conditions under which the fossils are found,

a discussion of the interrelationship of the forms of Paradoxides and descriptions of species and varieties. The new species are *Paradoxides eteminicus*, with five varieties, *breviatus*, *suricoides*, *malicitus*, *quacoensis*, *pontificalis*; *Paradoxides acadicus*, and *P. lamellatus* Hartt var. *loricatus*. The figures are very fair.

MATHEW, G. F.—Illustrations of the Fauna of the Saint John Group, No. 1. The Paradoxides. (Supplementary section describing the parts.) (Trans. Roy. Soc. Canada, section iv, 1883, pp. 271–279, pl. x. Montreal, 1884.)

Describes and illustrates some of the parts of the previously-described species.

MICKLEBOROUGH, JOHN.—Locomotory Appendages of Trilobites. (Geol. Magazine, 3d Decade, February, 1884, vol. I, No. ii, pp. 80–84. London.)

A reprint from the Journ. Cincinnati Soc. Nat. Hist., vol. VI, 1883.

MILLER, S. A.—Description of a Beautiful Star-fish and other Fossils. (Jour. Cincinnati Soc. Nat. Hist., April, 1884, vol. VIII, No. 1, pp. 16–20, pl. iv.)

Describes the following new species from the Cincinnati Group: *Palæaster magnificus*, *Gomphoceras faberi*, and *G. cincinnatiense*.

MYER, OTTO.—Notes on Tertiary Shells. (Proc. Acad. Nat. Sci., Philadelphia, 1884, pp. 104–112.)

The author identifies a few American forms with European ones in addition to those already identified by Mr. Heilprin, and describes the following new species from the Eocene sands of Claiborne, Ala.: *Tibiella marshi*, *Bulla biumbilicata*, *Cadulus depressus*. *Tibiella* is proposed as a new genus of *Pteropoda*, but no synopsis of generic characters is given. The new species are illustrated by cuts in the text.

NEUMAYER, M.—(Neu. Jahrb. für Min. Geol. und Pal. Stuttgart, 1884.)

The author notes the parallel position occupied by the Laramie group in Northwestern America and the intertrappean beds of the Deccan in Hindostan, both being placed between the Cretaceous and Eocene, and the resemblance of the fossil faunas is well brought out by a comparative list.

RINGUEBERG, E. N. S.—New Fossils from the Four Groups of the Niagara Period of Western New York. (Proc. Acad. Nat. Sci. Philadelphia, 1884, pp. 144–150, pls. ii and iii.)

Describes the following new species: *Sphirophyton archimedes*, *Triacrinus pyriformis*, *T. globosus*, *Stictopora obliqua*, *Fungispongia irregularis*, *Stictopora graminifolia*, *Eucalyptocrinus inconspectus*, *Cornulites contractus*, *C. nodosus*, *Lingula bicarinata*. The two genera *Triacrinus* and *Fungispongia* are described.

SCUDDER, S. H.—Triassic Insects from the Rocky Mountains. (Amer. Jour. Sci. and Arts., September, vol. XXVIII, pp. 199–203. New Haven, 1884.)

All but two or three of the specimens obtained belong to the group of cockroaches; and although Mr. Lesquereux thinks the beds of Permian age according to the fossil flora, Mr. Scudder thinks the evidence of the insects is in favor of their Triassic age. Eleven of the seventeen species of cockroaches and five of the nine genera found at Fairplay, Colorado, belong to the Palæoblattariæ. The genera are as follows: *Etoblattina* (1 sp.), *Petrablattina* (2 sp.), *Anthracoblattina* (1 sp.?), *Spiloblattina* n. g. (4 sp.), and *Poroblattina* n. g. (3 sp.). As seen above two of the genera are new.

SCUDDER, S. H.—Two New and Diverse Types of Carboniferous Myriapods. (Mem. Boston Soc. Nat. Hist., March, 1884, vol. III, No. ix, pp. 283–297, pls. xxvi and xxvii.)

A discussion of Carboniferous Myriapods. The author proposes the new suborder *Protozyngnatha* for the reception of the genus *Palæocampa* M. and W., and in the suborder *Archipolypoda*, in the family of the *Euphoberidæ*, he places and describes his new genus *Trichiulus*, and describes the following species: *T. villosus*, *T. nodulosus*, and *T. ammonitiformis*.

SCUDDER, S. H.—The Species of Mylacris, a Carboniferous Genus of Cockroaches. (Mem. Boston Soc. Nat. Hist., March, 1884, vol. III, No. x, pp. 299–309, pl. xxvii.)

Besides mentioning the previously described species, the author gives the following new ones: *Mylacris antiquum*, *M. lucifugum*, *M. carbonum*, *M. priscovolans*, and *M. ovale*. The illustrations of both of these articles are excellent.

SCUDDER, S. H.—A Contribution to our Knowledge of Paleozoic Arachnida. (Proc. Amer. Acad. Arts and Sci., June, 1884, pp. 13–22. Boston.)

This article contains both American and European forms. The new family *Poliocheridæ* is established and the new genus *Poliochera* is placed in it. The new family *Eoscorpionidæ* is also established and in it the genera *Eoscorpius*, *Cyclophthalmus*, and *Mazonia* are placed. The new genera *Geralinura* and *Geraphrynus* are described. The following new species are described: *Poliochera punctulata*, *Geraphrynus carbonarius*, *Anthracomartus trilobitus*, *A. pustulatus*, *Geralinura carbonaria*.

SCUDDER, S. H.—Dictyonema and the Allied Insects of the Carboniferous Epoch. (Proc. Amer. Acad. Arts and Sci., December, 1884, pp. 167–173. Boston.)

This is a brief paper in advance of a fuller memoir with detailed descriptions and full illustrations. Mr. Scudder establishes the new gen-

era *Litoneura*, *Polioptenus*, *Goldenbergia*, and describes the following new American species: *Titanophasma jucunda*, *Haplophlebium longipennis*, *Paolia superba*, *P. lacoana*, and *P. Gurleyi*. The author restricts the genus *Dictyoneura* to *D. Schmitzii* Gold., *D. humboltiana* Gold., *D. sinuosa*, Kliv., and *D. affinis*. (*Termes affinis*, Gold.).

SPENCER, J. W.—Niagara Fossils. (Bull. Mus. Uni. State of Missouri, pp. 1–61, pls. i–ix. Saint Louis, 1884.) Published also in Saint Louis Acad. Sci., vol. IV, No. 4.

This work is divided into three parts: Part i, "Graptolitidæ of the Upper Silurian system;" part ii, "Stromatoporidæ of the Upper Silurian system;" part iii, fifteen new species of Niagara fossils. Part one contains the descriptions of twenty-one new species: *Phyllograptus? dubius*, *Dendrograptus ramosus*, *D. Simplex*, *D. Dawsoni*, *D. frondosus*, *D. praegracilis*, *D. spinosus*, *Callograptus granti*, *C. multicaulis*, *C. minutus*, *Dictyoneura expansum*, *Calyptograptus micronematodes*, *C.? radiatus*, *Acanthograptus pulcher*, *Inocaulis walkeri*, *I. diffusus*, *I. cervicornis*, *I. phycoides*, *I. ramulosus*, *Thamnograptus? multiformis*, *Cyclograptus rotadentatus*, and of one new genus *Cyclograptus*; besides there are descriptions and illustrations of nine species previously described by the author in the Canadian Naturalist, 1878. In part ii the following new species are described: *Cannopora walkeri*, *C. mirabilis*, *Cœnostoma ristigonchense*, *Cœnostoma botryoideum*, *Dictyostoma reticulatum*. Part iii contains the following new species: *Palæaster granti*, *Rhinopora venosa*, *Clathropora? gracilis*, *Fenestella bicornis*, *Polypora* (*Fenestella?*) *albionensis*, *Lingula ingens*, *Discina clara*, *Crania anna*, *Pleurotomaria clipeiformis*, *Conularia rugosa*, *C. wilkinsi*, *Orthoceras bartonense*, *Cyrtoceras reversum*, *Lituites niagarensis*. It is much to be regretted that the illustrations are so poor that it will be very difficult, if not impossible, for future workers to recognize Mr. Spencer's types.

SPRINGER, FRANK.—On the Occurrence of the Lower Burlington Limestone in New Mexico. (Amer. Journ. Sci. and Arts, February, vol. XXVII, pp. 97–103. New Haven, 1884.)

The author endeavors to identify a formation in the Lake Valley mining district in Southern New Mexico with the lower Burlington limestone. For this purpose he gives a list of the fossils found there.

ULRICH, E. O.—American Palæzoic Bryozoa. (Jour. Cincinnati Soc. Nat. Hist., December, 1883, No. 4, vol. VI, pp. 241–279, pls. xii–xiv. Continued from Vol. VI, p. 168.)

In this portion of the work, Mr. Ulrich restricts the genus *Atactopora*, and establishes the new genera *Atactoporella*, *Idiotrypa*, *Anisotrypa*, and *Heliotrypa*. He describes the following new species: *Atactoporella typicalis*, *A. newportensis*, *A. schucherti*, *Trematopora halli*, *T. whitfieldi*, *Constellaria fischeri*, *Idiotrypa parasitica*, *Anisotrypa symmetrica*, *Heliotrypa bifolia*. The work is to be continued.

WALCOTT, C. D.—Paleontology of the Eureka District. (Monographs of the United States Geological Survey, vol. VIII, pp. i–xiii and 1–298, pls. i–xxiv, and seven figures in the text. Washington, 1884.)

Gives an account of the very interesting paleozoic fauna of this district. The first chapter contains a fair summary of the results. A commingling of Upper Devonian and Lower Carboniferous fossils occurs. The discussion of the development of *Olenellus Howelli* is very interesting. The succession in the faunal series from the Olenellus beds, through a well-defined fauna of the character of the Potsdam group of New York and the Mississippi Valley, to one containing a mixture of Cambrian and Silurian types passing upward to a fauna comparable to that of the Chazy and Calciferous groups, is shown. The transition is said to be very gradual, and such as would occur where there had been no marked physical disturbance. Here is another instance of the occurrence of passage beds between faunas before considered perfectly distinct, and it is very interesting to note this fact in our earliest faunas, which is so common in our later ones.

The author gives carefully prepared systematic lists of the fossils in each formation and a paleozoic section of Nevada showing the vertical range of the genera. Two new genera are described, *Schizambon*, referred to the Siphonotretidæ, from the L. Silurian Pogonip group and *Zaptychius*, an auricula-like shell, from the Carboniferous. The author describes one hundred and seventy-three new species, of which thirty are from the Cambrian: *Acrothele ? dichotoma, Scenella ? conula, Kutorgina whitfieldi, K: prospectensis, Orthis eurekensis, Stenotheca elongata, Agnostus richmondensis, A. seclusus, Olenellus iddingsi, Dicellocephalus nasutus, D. richmondensis, D. ? angustifrons, D. iole, D. marica, D. ? expansus, Ptychoparia ? prospectensis, P. ? linnarssoni, P. (Solenopleura ?) breviceps, P. ? (Solenopleura ?) pernasutus, P. (Euloma) dissimilis, P. (Euloma) Occidentalis, P. (Euloma) similis, P. (Euloma) affinis, P. (Euloma) laeviceps, P. (Petrocephalus) occidena, Anomocare ? parvum, Agraulos ? globosus, Arethusina americana, Ogygia ? spinosa, O. ? problematica.* From the Pogonip group of the Lower Silurian thirty-one species are described: *Receptaculites mamillaris* Newb. n. sp., *R. elongata, R. ellipticus, Obolella ambigua, Schizambon typicalis, Orthis hamburgensis, O. lonensis, Streptorhyncus minor, Tellinomya ? hamburgensis, Modiolopsis occidens, M. pogonipensis, Pleurotomaria lonensis, Maclurea annulata, M. subannulata, M. carinata, Metoptoma phillipsi, M. ? analoga, Coleoprion minuta, Hyolithes vanuxemi, Dicellocephalus finalis, D. inexpectans, Ptychoparia ? annectans, Bathyurus ? tuberculatus, B. ? congeneris, B. ? simillimus, Cyphaspis ? brevimarginatus, Amphion nevadensis, Symphysurus ? goldfussi, Barrandia ? McCoyi, Illaenurus eurekensis, Asaphus caribounensis.* From the Devonian sixty-one new species are described: *Palaeomanon roemeri, Lingula alba-pinensis, Lingula lonensis, L. whitei, Pholidops bellula, P. quadrangularis, Ikercidium devonicum, Chonetes macrostriata, C. filistriata, Productus (Productella) hallanus, Productus hirsutiforme, Cyrtina david-*

soni, Trematospira infrequens, Rhynchonella ? occidens, R. (Leiorhynchus) nevadensis, Pentamerus lotis, Cryptonella ? circula, C. pinonensis, Pterinea newarkensis, Leptodesma transversa, Limoptera sarmenticia, Mytilarca dubia, Modiomorpha altiforme, M. oblonga, M. obtusa, Nucula rescuensis, Dystactella insularis, Megambonia occidualis, Nyassa parva, Grammysia minor, Sanguinolites ? combensis, S. ? gracilis, Conocardium nevadensis, Poridonomya laevis, P. devonica, Microdon (Cypricardella) macrostriatus, Anodontopsis amygdalaeformis, Schizodus (Cytherodon) orbicularis, Platyceras conradi, P. undulatum, P. thetiforme, Euomphalus eurekensis, Ecculiomphalus devonicus, Straparollus newarkensis, Platyschisma ? McCoyi, P. ? ambiguum, Callonema occidentalis, Loxonema eurekensis, L. nobile, L. approximatum, Bellerophon perplexa, B. combsi, Scoliostoma americana, Metoptoma ? devonica, Coleolus laevis, Gomphoceras suboviforme, Cyrtoceras nevadense, Goniatites desideratus, Beyrichia (primitia) occidentalis, Leperditia rotundata, Dalmanites meekii. From the Carboniferous fifty-one new species are described: *Discinna connata, Spirifera annectans, S. desiderata, Rhynchonella eurekensis, R. thera, Aviculopecten haguei, A. eurekensis, A. peroccidens, A. pintoensis, A. affinis, Strebloptera similis, Crenipecten hallanus, Pterinopecten hoosacensis, P. spio, Pterinea pintoensis, Ptychopteria protoforme, Pinna inexpectans, P. cosimilis, Myalina congeneris, M. nemesis, M nessus, Modiola nevadensis, Modiomorpha ambigua, M. ? desiderata, M. ? pintoensis, Nucula insularis, N. levatiforme, Solenomya curta, Macrodon truncatus, Edmondia medon, E. ? circularis, Pleurophorus meeki, Sanguinolites retusus, S. simplex, S. salteri, S. ? naenia, S. striatus, Microdon (cypricardella) connatus, Cardiola ? filicostata, Schizodus deparcus, S. curtiforme, S. pintoensis, Platyceras occidens, P. piso, Platyostoma inornatum, Bellerophon majusculus, Loxonema bella, Pleurotomaria nevadensis, Metoptoma peroccidens, Hyolithes carbonaria, Orthoceras eurekensis.*

The discovery in the Devonian of the interior of a dorsal valve of a rather large species of Lingula, *Lingula whitei*, afforded the means of comparison of the same parts of the shell with a Silurian and recent species of this genus, and proves the great structural similarity of the three species so widely separated in geological time.

WALCOTT, C. D.—On the Cambrian Faunas of North America. Preliminary studies. (Bull. U. S. Geol. Surv., vol. II, No. 10, pp. 283–354, pls. i–x. Washington, 1884.)

This work consists of three parts; the first "a review of the fauna of the Saint John formation, contained in the Hartt collection." This work is not meant to encroach on Mr. Mathew's work, and contains merely illustrations and descriptions of specimens in the Hartt collection belonging to Cornell University, and Mr. Mathew proposed specific names for the new species excepting one, *Harttia mathewi*, the type of the n. g. *Harttia* Walcott, a very curious form belonging to the *Calyptræidæ*. The new species are *Lingula ? dawsoni* Mathew, *Hyolithes danianus*, and *H. micmac* Mathew. *Conocoryphe walcotti* Mathew is also mentioned here for the first time. The new subgenus *Salteria* is pro-

posed in place of the generic use of the name *Erinnys* anticipated. Mr. G. F. Matthew having proposed the name *Bailiella*, *Conocoryphe* (*Bailiella*) *baileyi*, this name will be substituted for *Salteria*, in referring to the St. John species. Mr. Walcott does not accept the genus *Conocephalites*, and refers its different species to some of *Ptychoparia* and one of *Conocoryphe*.

The second part is on the "fauna of the Braintree argillites." Mr. Walcott gives excellent figures of *Paradoxides harlani* and doubts its specific difference from *P. bennetti*. He describes two new species from this formation, *Hyolithes shaleri* and *Ptychoparia rogersi*, and refers Whitfield's *Arionellus quadrangularis* to the genus *Agraulos*.

Part three contains the description of a new genus and species of *Phyllopoda* from the middle Cambrian slates of Parker's farm, Georgia, Vt., *Protocaries n. g.* type *P. marshi*. The illustrations are all woodcuts, and are very good of their kind.

WALCOTT, C. D.—Appendages of the Trilobite. (Science, No. 57, March 7, vol. III, pp. 279–281. Cambridge, 1884.)

An interesting paper on the appendages of the *Asaphus megistos*, described by Prof. John Mickleborough. Mr. Walcott notes the verification of the hypothesis that the legs were jointed beneath the pygidium as the only addition to our knowledge furnished by this specimen. An excellent figure accompanies the paper; there are also figures of *Calymene senaria*, copied from those in Bull. Mus. Comp. Zool., Vol. VIII, p. 204, 1881.

WARD, L. F.—On Mesozoic Dicotyledons. (Amer. Journ. Sci. and Arts, April, vol. XXVII, p. 293. New Haven, 1884.)

Mr. Ward reviews briefly the present condition of our knowledge of the subject, and gives a history of its progress, and some generalizations and attempts at comparisons with European beds.

WARD, L. F.—*Caulinites* and *Zamiostrobus* (Science, No. 65, May 2, vol. III, pp. 532, 533. Cambridge, 1884.) An answer to J. F. James's "Two species of Tertiary Plants."

WHITE, C. A.—A Review of the Fossil Ostreidæ of North America, and a Comparison of the Fossil with the Living Forms. With appendices by Prof. Angelo Heilprin and Mr. John A. Ryder. (Rep. of the Sec. of the Interior for 1883, vol. III. Rep. of the director of the U. S. Geol. Surv., pp. 273–430, pls. xxxiv to lxxxii. Washington, 1883.) [Appeared 1884.]

A valuable condensation of the known North American oysters, with copious illustrations. The plan is the same as that followed in the Review of the Non-marine Fossil Mollusca published the year previous.

WHITE, C. A.—On a small Collection of Mesozoic Fossils collected in Alaska by Mr. W. H. Dall, of the United States Coast Survey. (On Mesozoic Fossils. Bull. U. S. Geol. Surv., vol. I, No. 4, pp. 98–103, pl. vi. Washington, 1884.)

The author describes a variety of *Aucella concentrica* Fisher, a new species *Cyprina ? dallii*, and a long very slim cephalopod, *Belemnites macritatis*. He discusses the age of the strata containing them, and concludes that they occupy a transitional position between the Cretaceous and Jurassic, as indicated by Mr. J. Marcou.

WHITE, C. A.—Description of certain Aberrant Forms of the Chamidæ from the Cretaceous Rocks of Texas. (On Mesozoic Fossils. Bull. U. S. Geol. Surv., vol. I, No. 4, pp. 93–97, pls. i–v. Washington, 1884.)

Describes the following new species: *Requienia patagiata*, *Monopleura marcida* and *M. pinguiscula*. Numerous figures accompany the descriptions.

WHITE, C. A.—On the Nautiloid Genus *Enclimatoceras* Hyatt, and a description of the type species. (On Mesozoic Fossils. Bull. U. S. Geol. Surv., vol. I, No. 4, pp. 104, 105, pls. vii–ix. Washington, 1884.)

The generic description is by Mr. A. Hyatt, and the specific description of *E. ulrichi* is by Mr. C. A. White.

WHITE, C. A.—On the *Macrocheilus* of Phillips, *Plectostylus* of Conrad, and *Soleniscus* of Meek & Worthen. (Proc. U. S. National Museum, vol. VI, pp. 184–187, pl. viii. Washington, 1883.)

Refers to *Soleniscus* a number of species previously described as *Macrocheilus*.

WHITE, C. A.—Enemies and Parasites of the Oyster, past and present. (Science, vol. III, p. 618. Cambridge, 1884.)

The author shows that *Cliona* or a similar burrowing sponge infested certain brachiopod shells as early as the Devonian, and that similar forms were as common upon the fossil Ostreidæ as they are upon the living. He also shows that the remains of star-fishes are rarely found with fossil Ostreidæ, although they are so common an enemy to living oysters.

WHITE, C. A.—The Fossils of the Indiana Rocks, No. 3. (Indiana department of Geol. and Nat. Hist. (thirteenth annual report), part ii, Palaontology, pp. 107–180, pls. 23–39. John Collett, State geologist. Indianapolis, 1884.)

In this work Mr. White gives excellent descriptions of the characteristic invertebrate animal remains of the Carboniferous period, illustrated by figures drawn by Mr. McConnell. Many of the figures are borrowed from previous works, but their execution is good and gives an excellent idea of the characteristic Carboniferous forms of the central coal basin.

WHITEAVES, J. F.—Mesozoic Fossils. Vol. I, part iii. On the fossils of the coal-bearing deposits of the Queen Charlotte Islands, collected by Mr. G. M. Dawson in 1878. (Geol. and Nat. Hist. Survey of Canada, pp. 191–262, pls. 21–32. Montreal, April, 1884.)

In this report the fossils occurring in a section 13,000 feet thick are described as Cretaceous. The three lower beds, aggregating 9,500 feet

in thickness, are supposed to represent the lower part of the middle Cretaceous, notwithstanding the fact that they contain many fossils considered Jurassic by previous American authors. However, the identity of these species is very doubtful. The upper division, containing *Inoceramus problematicus*, is 1,500 feet thick and is separated from the three lower divisions by 2,000 feet of unfossiliferous strata, the whole mass resting unconformably upon what is considered the Triassic. The author is driven by his conclusions to assert that the Jurassic of the Black Hills and Rocky Mountains is Cretaceous. In order to make a more complete Cretaceous series, he cuts out the entire Jurassic formation. Mr. Whiteaves seems to have overlooked the work of Mr. C. Grewingk, who described the fossils brought back by Ilia Wossnessensky, the work of Eichwald, who described the fossils brought back by Doroschin, and that of Pinart, all three describing a somewhat similar fauna in Russian America. He has also not noticed the fact that traces of a Jurassico-cretaceo fauna occur from the neighborhood of Moscow, through Siberia to Alaska, and that very possibly he has similar passage beds in British Columbia and Queen Charlotte's Islands, that such passage beds are found between every formation, and that the occurrence of some of our Jurassic fossils in such a connection is a poor reason for calling Cretaceous the beds where there is no such association.

The following new species are described: *Belemnites skidegatensis ?*, *Spiroceras carlottensis*, *Sphenodiscus mandensis*, *Haploceras cumshewaense*, *Stephanoceras oblatum*, *Stephanoceras cepoides*, *Hamites ? glaber*, *Nerinæa mandensis*, *Cerithium skidegatense*, *Vanikoro pulchella ?*, *Calliostoma constrictum*, *Cinulia pusilla*, *Corbula concinna*, *Periploma cuspidatum*, *Thracia semiplanata*, *Tellina skidegatensis*, *Thetis affinis ?*, *Cyprina occidentalis*, *Trigonia mandensis*, *Yoldia arata*, *Trigonoarca tumida*, *Lithodomus mandensis*, *Melina skidegatensis*, *Inoceramus moresbyensis*, *Amusium lenticulare ?* *Ostrea skidegatensis ?*, *Astrocœnia irregularis*, *Schloenbachia propinqua*, *Cardium tumidulum*, *Pecten carlottensis*, *Rhynchonella mandensis*, *Discina semipolita*.

WHITEAVES, J. F.—On the Lower Cretaceous Rocks of British Columbia. (Trans. Roy. Soc. Canada, section iv, 1882, pp. 81–86.)

Describes three new species, illustrated by three woodcuts in the text: *Olcostephanus quatrinoensis*, *Pholadomya vancouverensis*, *Inoceramus quatsinoensis*. Mr. Whiteaves holds with Eichwald that the presence of an abundance of *Aucellæ* is a sure proof of the Neocomian age of the rocks in which they occur.

WHITEAVES, J. F.—On some supposed Annelid tracks from the Gaspé Sandstone. (Trans. Roy. Soc. Canada, section iv, 1882, pp. 109–111, pls. xi and xii.)

Mr. Whiteaves proposes the name of *Gyrichnites gaspensis* for certain supposed annelid tracts of the Lower Devonian of Point Gaspé, and illustrates them on two plates, unfortunately on a reduced scale.

WHITEAVES, J. F.—Paleozoic Fossils. (vol. III, part 1, Geol. and Nat Hist. Surv. Canada. Montreal, March, 1884, pp. 1–43, pls. i–viii.)

This part is on some new, imperfectly characterized, or previously unrecorded species of fossils from the Guelph Formation of Ontario. The lists of the fossils of this formation in the "Geology of Canada" contain the following names, for the species of which no descriptions or figures have ever been published, and which, consequently, it has been impossible to recognize: *Columnaria galtensis, Diphyphyllum irregulare, Amplexus lascatus, Cyclonema galtensis, C. Thysbe, C. Psyche, C. depressa, Pleurotomaria huronensis, Murchisonia tullia, Cyrtoceras jonesi.* The present author describes two new genera, *Pycnostylus* and *Codonocheilus*, and the following new species: *Pycnostylus guelphensis, P. elegans, Monomerella ovata, M. ovata* var. *lata, Goniophora crassa, Anodontopsis concinna, Tlionia galtensis, T. ? costulata, Subulites compactus, Codoncheilus striatum, Trochonema inornatum, Straparollus crenulatus, Pleurotomaria cyclostoma, P. durhamensis, Murchisonia hespelerensis, M. constricta, M. soluta, M. tropidophora, Tryblidium canadense, Scenella conica, Ecculiomphalus circinatus, Ascoceras townsendi, Eurypterus boylei.*

WHITFIELD, R. P.—Notice of some new Species of Primordial Fossils in the Collections of the Museum, and Corrections of previously described Species. (Bull. Amer. Mus. Nat. Hist., February, 1884, vol. I, No. 5, pp. 139–154, pls. xiv and xv. New York.)

Mr. Whitfield thinks that the typical New York Potsdam is about equivalent to the lower portion of the Wisconsin areas, and that the Acadian beds of Canada and Vermont and perhaps the other Atlantic areas are not appreciably different in age, but that the difference in faunæ is more the result of conditions upon which life depended than a difference in time. Mr. Whitfield was probably unaware of the fact that 3,000 feet of limestone without a break separate the Georgian from the Potsdam fauna in Central Nevada. He describes the following new species: *Lingulepis minima, Orthisina orientalis, Nothozoe vermontana, Conocephalites verrucosus, Arionellus quadrangularis, Angelina hitchcocki, Dikellocephalus ? marcoui, Maclurea wadsworthi.*

WILLIAMS, H. S.—On the Fossil Faunas of the Upper Devonian along the Meridian 76° 30′ from Tompkins County, New York, to Bradford County, Pennsylvania. (Bull. U. S. Geol. Surv., vol. I, No. 3, pp. 55–86. Washington, 1884.)

This paper is the first of a series; it contains an interesting discussion of the relative positions of the Upper Devonian faunas of the meridian of Ithaca, N. Y. Mr. Williams does not always explain clearly where his stations, designated by numbers, are located.

WILLIAMS, H. S.—The Spirifers of the Upper Devonian. (Science, vol. III, pp. 374, 375. Cambridge, 1884.)

The author criticises the stratigraphical position assigned to some of the fossil species in Report of Progress G. 7, 2d Geol. Surv. of Pennsylvania.

WOODWARD, H.—On the Structure of Trilobites. (Geol. Magazine, 3d Decade, February, 1884, vol. I, No. 2, pp. 78, 79. London.)

A reproduction of the author's views on the appendages of trilobites, and *Asaphus platycephalus* Stokes, in particular, as published in 1871 in the Geol. Magazine, July, pp. 289–294, pl. viii.

WOODWARD, H.—Notes on the Appendages of Trilobites. Note to accompany three woodcuts of *Asaphus megistos*, a Trilobite discovered by Mr. James Pugh, near Oxford, Ohio, in the upper portion of the Hudson River group. (Geol. Magazine, 3d Decade, April, 1884, vol. I, No. 4, pp. 162–165. London.)

Reproduces Mr. John Mickleborough's figures of *Asaphus megistos* with a few remarks. He suggests, concerning Mr. Walcott's restoration of *Calymene senaria*, that the last seven pairs of appendages belonging to the pygidium were more probably lamelliform branchigerous appendages as in Limulus and in living isopods. (See Mr. Walcott's article in Science, vol. III, pp. 279–281.)

WORTHEN, A. H.—Descriptions of two new species of Crustacea, fifty-one species of Mollusca, and three of Crinoids, from the Carboniferous formations of Illinois and adjacent States. (Bull. No. 2, Illinois State Mus. Nat. Hist., March, 1884, pp. 1–27. Springfield, Ill.)

No illustrations accompany the descriptions of these species: *Colpocaris chesterensis*, *Solenocaris St. Ludovici*, *Nautilus montgomeryensis*, *Pleurotomaria illinoiensis*, *P. giffordi*, *P. adamsi*, *P. nauvooensis*, *P. coxana*, *Porcellia peoriensis*, *Loxonema peoriensis*, *L. quadricarinatus*, *Orthonema carbonaria*, *Trachydomia nodulosa*, *Bellerophon giganteus*, *Naticopsis madisonensis*, *Polyphemopsis ? keokuk*, *Schizodus magnus*, *S. varsoviensis*, *S. nauvooensis*, *S. depressus*, *S. ? circulus*, *Allorisma illinoiensis*, *A. elongata*, *Solenomya varsoviensis*, *S. monroensis*, *S. iowaensis*, *Aviculopinna illinoiense*, *Sanguinolites ? multistriatus*, *S. burlingtonensis*, *Bakevellia illinoiensis*, *Myalina monroensis*, *Nucula illinoiensis*, *Modiola illinoiensis*, *Cardiomorpha ? pellaensis*, *Pleurophorus chesterensis*, *P. minima*, *P. monroensis*, *Edmondia varsoviensis*, *E. illinoiensis*, *Aviculopecten orestes*, *A. niotense*, *A. elsahensis*, *A. chesterensis*, *A. spinuliferus*, *A. monroensis*, *A. talboti*, *A. colletti*, *A. edwardsi*, *Lima ? menardi*, *Discina varsoviensis*, *Terebratula rowleyi*, *Athyris squamosus*, *Rhynchonella illinoiensis*, *Lingula varsoviensis*, *Lepetopsis chesterensis*, *Batocrinus montgomeryensis*, *B. subconicus*, *Poteriocrinus spinuliferous*. The typical specimens will be placed on exhibition in the cases of the State museum.

ZOOLOGY.

By Professor THEODORE GILL.

INTRODUCTION.

Investigations into the secrets of the animal world have been conducted by most of the investigators prominent for the past few years, and by the usual number of recruits to the ranks of zoologists. The addition to our knowledge of the various types of the animal kingdom has been substantial and important, but as usual chiefly confined to matters of detail and refinement, which can be only appreciated by the skilled biologist. Some noteworthy discoveries that can be set forth in a few words, and whose importance can readily be appreciated by all have likewise been made. Among them are the find of a Silurian scorpion which takes the class of Arachnids much farther back in time, a like extension backwards of the fishes by the exhumation of remains near the base of the upper Silurian beds of Pennsylvania, by Mr. Claypole, and the confirmation of the oviparity of the Monotremes, of the only two known family types (Ornithorhynchids and Tachyglossids), by Messrs. W. D. Caldwell and W. Haacke, as well as some insight into their embryonic stages.

There are also two features of special interest as signs of the time, in the accessions to the ranks of true investigators from sources from which in times past none looked for work of an exact or highly original nature; such are the female sex and people formerly called barbarous.

A most pleasant feature is the number of recent female contributors, and there is a most laudable absence of ignorant wonder and congratulation in all of them. America and England have been especially fortunate in the number of able female investigators. We may be pardoned for recalling the names of a few. In the United States, Miss Rosa Smith, of San Diego, Cal., has described new species and a genus of fishes; Miss Katherine J. Bush has published a useful catalogue of mollusca and echinodermata of Labrador; Miss Mary H. Hinckley has made known the habits and transformations of a tree-frog (*Hyla Pickeringii*) in a special monograph; Miss Sara Gwendolen Foulke has made known the structure and habits of many of the lower forms of animal life; Miss Mary Esther Murtfeldt has given several communications on

insects; and Miss Genevieve Jones and Miss Eliza Schulze have given to the world a most magnificent illustrated work on the nests and eggs of the birds of Ohio. In England, Miss E. A. Ormerod has published excellent reports on the insects affecting agricultural interests; Miss Catherine C. Hopley has been active in the study of reptiles, and especially the snakes, and published a very creditable volume on the latter; Miss Agnes Crane has contributed to the history of Brachiopods, Polyzoans, and other animals; and Miss Alice Johnston has attacked, with a well-equipped mind and training, some of the most profound problems in morphology. Further, we may name two who have done excellent work in presenting in popular form the results of recent researches, Miss Arabella Buckley, and Mrs. Martin, who, in conjunction with her husband, Professor Martin, of the Johns Hopkins University, has published a manual of physiology.

Distant and formerly isolated Japan has also furnished to the scientific corps a notable contingent, who have demonstrated the ability of the Mongolian race to hold their own with the best of the Caucasians. Professor Kakichi Mitsikuri, a graduate of the Johns Hopkins University, and now professor of zoology in the University of Tokio, and Dr. Isao Iijima have been working successfully in fields wherein only the best trained minds, supplemented by extraordinary skill in anatomy and manipulation generally, can hope for success. Laborers such as these, of either sex or any country, will always be welcome.

A pleasant and in some ways an important event of the year was the meeting, for the first time in its long history, of the British Association for the Advancement of Science on American soil or even outside of the British Isles. The session at Montreal in September was as largely attended as could have been expected under the circumstances, and there was a pleasant interchange of courtesies between the association and its younger American sister. Many naturalists long known to each other by reputation, and often through correspondence, met face to face for the first time, and doubtless misapprehensions were rectified, better knowledge of each other obtained, mutual respect insured, and personal friendship cemented.

As in the previous reports, the language of the original from which the abstract is compiled is generally followed as closely as the case will permit. It has, however, been found necessary to limit the abstract to the illustration of the prominent idea underlying the original memoir, and pass by the proofs and collateral arguments. At the same time it has been often attempted to bring the new discovery into relation with the previous status of information respecting the group under consideration. As to the special discoveries recorded, they have been generally selected (1) on account of the modifications the forms considered force on the system; or (2) for the reason that they are or have been deemed to be of high taxonomic importance; or (3) because the animals *per se* are of general interest; or, finally, (4) because they

are of special interest to the American naturalist. Of course zoologists cultivating limited fields of research will find in omissions cause for censure, and may urge that discoveries of inferior importance have been noticed to the exclusion of those better entitled to it. It is freely admitted that this charge may even be justly made; but the limits assigned to the record have been much exceeded, and the recorder has studied the needs of the many rather than of the few. The summary is intended, not for the advanced scientific student, but for those who entertain a general interest in zoology or some of the better-known classes.

A very partial bibliography of noteworthy memoirs and works relating to different class of animals is supplied, and will, it is hoped, prove to be of use to some to whom the voluminous bibliographies and records of progress in science are inaccessible.

It has been a difficult matter to select the titles which might be most advantageously introduced in a limited report like the present. Articles of a general interest or of special importance as contributing to throw light on the affinities of certain groups, or monographs have been given the first place. Necessarily many very important papers have not been referred to, and very few descriptive of species have been admitted, and only when unusual interest attaches to the new species or the groups which they enlarge.

The compiler desires to make special acknowledgment for most material assistance to the *Zoologischer Anzeiger* of Professor Carus and to the *Journal of the Royal Microscopical Society*.

SYNOPSIS OF ARRANGEMENT.

I. GENERAL ZOOLOGY.

The deep-sea researches of the United States Fish Commission in 1884.

Professor Verrill has given an account of the work of the steamer Albatross in 1884. The exploration of the Gulf Stream region was continued under nearly the same conditions as in 1883, and four trips

were made between July 20 and September 13. Sixty-nine dredgings were made. Of these, five were in depths between 2,000 and 2,600 fathoms and the rest in less deep water. The results were "highly satisfactory, both in the way of physical observations and zoological discoveries." Large numbers of additions were "made to the fauna, including representatives of nearly all classes of deep-sea animals. Many pelagic species were also secured in surface nets, and especially in the trawl-wings. Among these there are some new forms, and many of them have previously not been observed so far north and near the Gulf Stream."

The deep-sea deposits were especially noteworthy. "The bottom between 600 and 2,000 fathoms, in other regions, has generally been found to consist mainly of 'globigerina ooze,' or sometimes of a mixture of globigerina and pteropod ooze. Off our northern coast, however, this is by no means always the case. The ooze is always mixed with some sand and frequently with much clay-mud. In a number of instances the bottom, between 500 and 1,200 fathoms, has been found to consist of tough and compact clay, so thoroughly hardened that many large angular masses, sometimes weighing more than fifty pounds, have been brought up in the trawl."

The animals obtained were sometimes of singular interest. "Many additions to the fauna of great depths were made, and a large portion of them are undescribed forms. Some of the fishes were of great interest. Huge spiny spider crabs (*Lithodes Agassizii*) over three feet across were taken in 1,000 to 1,230 fathoms, and another very large crab (*Geryon quinquedens*) occurred in great abundance in 500 to 1,000 fathoms." Numerous species of handsome shrimps, many "of a bright color and some of very large size, occurred as usual in the deeper dredgings. Some of these had not been taken before."

Of the Echinoderms, the star-fishes were numerous, and two species of a very singular genus, called *Brisinga*, were obtained in many localities, sometimes in large numbers. Ophiurans of many species were also obtained in numerous localities. (*Am. Journ. Sc.* (3), XXVIII, pp. 378–384.)

Origin of the deep-sea fauna.—In a monograph of the Pourtalesiidæ, a family of deep-sea Echinoidea, Professor Sven Loven has expre sed some thoughts respecting the origin of the deep-sea fauna, and suggested how the forms characteristic of the depths may have been evolved, distributed, and modified from species of the littoral zone.

"In the adult state most of the marine evertebrates remain in their native station, wandering within its precincts. Their embryonic and larval age is their period of dispersal. Of numerous littoral forms, of different classes, tribes, and orders, currents must occasionally carry away the free swimming larvæ far into the sea, and during the course of succeeding generations early stages of many a species will have in this

way reached the wide ocean. There they will have sunk, their development accomplished all through depths full of danger and more and more uncongenial, and a few of them will have settled on the bottom of the abyss, and fewer still will have come to thrive there. Among these some will long have their original character, and but slowly been modified, while others will have exhibited a latitude of variation unknown or rarely seen where they came from, but upon the whole there will be reasons for assuming the less altered forms to be new comers, the more deviating to be old inhabitants of the deep."

Organisms in ice.—A Philadelphia gentleman gave Prof. Joseph Leidy, for examination, a vial of water obtained from a lump of ice which had been used to cool ordinary drinking water. "From time to time, among some sediment taken from the water-cooler, the gentleman had observed what he supposed to be living worms, which he suspected were introduced with the water into the cooler and not with the ice." On examination of the water melted from this ice, Professor Leidy was "surprised to find a number of worms among some flocculent sediment, mainly consisting of vegetal hairs and other *débris*. Besides the worms, there were also immature Anguillulas, and a number of *Rotifer vulgaris*, all living. It would appear that these animals had all been contained in the ice, and had been liberated on melting. It was an unexpected source of contamination of our drinking water that Professor Leidy had previously supposed very improbable. The little worms he was not familiar with."

A study of the worms showed that "they belong to the family *Lumbricidæ*, and probably may be an undescribed species of *Lumbriculus*. They are white or colorless, from 4 to 6 millimeters long by a third of a millimeter in thickness;" there are about thirty segments. "Several dead worms swarmed in the interior with large, ovate, beaked, ciliated infusoria, measuring from 0.05 to 0.06 ^{mm} long by 0.04 to 0.048^{mm} broad." (*Proc. Acad. Nat. Sc. Phila.*, 1884, p. 260.)

Microscopic fauna in water reservoirs.—An accidental breaking of a valve, necessitating the drawing off of the water from the Fairmount reservoir, was taken advantage of by Mr. Edward Potts to study the minute fauna to be found.

"The commensal habit of many of the lower animals who feed by the creation of ciliary whirlpool currents has been frequently referred to; the weaker current-makers, such as vorticellæ, stentors, and the errant and tubicolous rotifers, planting themselves about the heads of the stronger polyzoa to supply their own nets with what may have escaped from the others. The same instinctive principle which leads all these to locate themselves most plentifully amongst the stones in the rapids of streams, was particularly noticeable in promoting their aggregation upon and in the neighborhood of the inlet and outlet gates

of the reservoirs. The feeble currents produced by each can only bring within its reach the floating provision from a very limited area; the volume of water poured through these gates brings to them a rich supply, and the numbers and variety of these organisms increase in proportion. Of the fixed forms were seen amongst the bryozoa, besides one or more undetermined species of *Plumatella*, *Pectinatella magnifica*, and *Urnatella gracilis* of Leidy, and the newly described *Paludicella erecta*. Attached to these were vorticellæ, epistilis, and stentors innumerable; *Pyxicola* and *Acineta*, rotifers of various names, including prominently *Limnias* and other probably undescribed forms among the melicertidæ. Very abundant among these was the interesting chaetobranch annelid, *Manayunkia speciosa* Leidy, which has of late been frequently noticed in this vicinity, and the wonderfully marine-looking hydroid *Cordylophora lacustris*. This last was particularly abundant around the southeast outlet, its stems forming a complete matting over many yards of surface, commingled with bryozoa and sponges in intricate confusion." (*Proc. Acad. Nat. Sc. Phila.*, 1884, pp. 217–219.)

Symbiosis of Hermit Crab and Sea-Anemone.—The subject of Symbiosis, or the association for mutual benefit of different animals, or, may be, of an animal and a plant even, has of late been attracting much attention. The name was first suggested by the French botanist, De Bary, in connection with certain phenomena of the vegetable world. The associates come together and associate "like two partners in a well regulated business concern, co-operating in the work of life, taking part in all its toils and troubles, and honorably sharing the common profits." The symbiotic relationship of one of the hermit crabs and a sea-anemone (*Adamsia palliata*) has been studied in the Naples aquarium by Professor Hertwig. The sea-anemone, a beautiful species, "attaches itself to the roof of the common abode in such a position that its mouth and prehensile apparatus are always turned toward the head of its associate. It is thus enabled to join in all the expeditions of the restless hermit crab and conveniently share in the common plunder. In return for this service the anemone protects its companion from his many enemies by means of the numerous long threads which it shoots out at the least alarm, and which are provided with millions of capsules charged with a stinging acid like that of the common nettle. So close is the compact entered into by the two partners that both have become indispensable to each other," and, "if the crab be removed from his house, and this be stopped up so as to prevent his re-entering it, he will cast about for another shell, and never stop until his old associate is also transferred to their new abode." Many similar cases of symbiosis of actinians and decapod crustaceans are now known, and the relationship is probably as intimate in almost all cases as the one studied. (*Am. Nat.*, XVIII, pp. 83, 84.)

II. PROTOZOANS.

Sporozoans.

A new Sporozoan type.—In 1883 Dr. A. Schneider described a new type of Sporozoans to which he gave the name *Ophryocystis butschlii.* Later studies have not only confirmed the distinctness of the form, but revealed characteristics so different from those manifested by others of the class, as to have impelled the author to distinguish it as the type of "a new order of Amœbosporidia." The Amœbiform stage is very versatile in its phases and has "a facies altogether different to that of any known Sporozoan;" there is "a large number of nuclei," and in this respect it presents an analogy "to certain Amœbina, and distantly to the Myxosporidia." A "conjugation of two always uninuclear individuals has been observed, but conjugation is not known among the Coccidia, and this peculiarity allies *Ophryocystis* to the most differentiated Gregarines. The mode of sporulation allies them possibly to the Myxosporidia, while, on the other hand, the production of falciform bodies or sporozoites in the spores is the exact opposite of what takes place in the Myxosporidia." In fine, the process of conjugation and the mode of sporulation distinguishes Ophryocystids "from the Coccidia, as do the pseudopodia and the sporulation from the Gregarinidæ, and the falciform corpuscles from the Myxosporidia." (*Arch. Zool. Expér. et Gén.*, II, pp. 111–126, 1 pl.; *J. R. M. S.* (2), V, pp. 82–83.)

Rhizopods.

A continental Foraminifer.—The Foraminifers hitherto known are inhabitants of the ocean, and the discovery of a species of the order in saline continental waters is therefore of unusual interest. The form in question proved to be not only a new species but a previously unknown generic type. Its infusorian companions were mostly of marine types of new species or conspecific with already known sea-forms, but "a fourth of the whole number are only known as fresh-water forms."

The new foraminiferous genus has been named *Entzia* and belongs to the group of *Helicostegia;* the shell in form resembles the *Rotalinæ* of the group *Globigerinæ*, in structure the *Trochamminæ*, and "the chemical constitution is that of *Difflugia*, *Trochammina*, and some of the *Globigerina;*" it is stated that it closely connects the last with the *Lagenidæ* by means of *Trochammina* and the *Rotalinæ.* (*Zeitschr. f. wiss. Zool.*, XL, pp. 465–480; *J. R. M. S.* (2), IV, pp. 760–761.)

Dimorphism in Orbulina.—Long ago it was shown that in the interior of the foraminiferous "shells" of the *Orbulina* type or genus were globigerina-like bodies, and it was even urged that one was a stage of the other. Valid objections, however, were brought against this view, but the relations of the two required elucidation. Recently numerous specimens of *Orbulina universa*, most of which were dredged from a

depth of about 2,000 fathoms by the "Talisman," were subject to a critical examination by C. Schlumberger. The appearance previously indicated was observed anew; "a succession of globular chambers, arranged in a spiral fashion, like those of certain *Globigerinæ*," were found within the shells of some of the small *Orbulinæ*, but not in all. In many, even of the small ones, no manifestation whatever of such contents existed, and "the very large specimens also were nearly always empty." Further, on minute examination it was discovered that there were essential histological and structural differences between the globigerina-like bodies of *Orbulinæ* and true *Globigerinæ*.

The "plasmostracum" of the globigerina-like contents of the *Orbulinæ* is "extremely fine and traversed by widely scattered perforations;" the chambers forming the two first turns of the spiral are quite smooth, while the following ones are provided with spines which reach as far as the outer wall of the *Orbulina* and are there fixed firmly to it, and the several chambers communicate with each other and also with the interior of the *Orbulina*.

The plasmostracum or cell-walls of the true *Globigerinæ* are relatively thick, and punctured by closely approximated and numerous perforations.

In fine, the resemblance between the contents of the *Orbulinæ* and true *Globigerinæ* is simply superficial, and, apparently, the most probable explanation is that *Orbulina* is another instance of dimorphism among the Foraminifers such as has already been shown to exist in other genera of that order by the author and Munier-Chalmas. (*Comptes Rendus*, XCVIII, pp. 1002–1004; *J. R. M. S.* (2), IV, pp. 579–580.)

Life history of a Helizoan Rhizopod.—The life history of a beautiful Heliozoan, named *Clathrulina elegans*, has been studied by a lady of Philadelphia, Miss Sara Gwendolen Foulke. This little rhizopod was found "in myriads" attached to the roots of the Duck weed or Lemna. In many cases they were seen in groups of "about twenty-five colony-stocks, so matted together by the twisting of the pedicels, and so surrounded by waste matter, as completely to conceal at that point the supporting root fibre. The animals were in a most active condition, feeding by means of their characteristic pseudopodial rays, and multiplying so freely by self-division, that the water was full of the Actinophrys-like bodies, and almost every capsule supported from one to ten young individuals. After being kept in captivity for two weeks, the large social groups had decreased in number, although solitary individuals were much more numerous. Reproduction was still going on, but not so freely, and by more varied methods. The phenomena exhibited during the act of reproduction are the subject of this communication.

"The modes of reproduction are four in number, two of these being slightly similar, while the others essentially differ in character. These

four modes are: *first*, by division; *second*, by the instantaneous throwing off of a small mass of sarcode; *third*, by the transformation of the body into flagellate monads; and *fourth*, by the formation and liberation of minute germs.

"By the *first* mode (and this is the most common), the sarcode mass within the capsule withdraws its rays, constricts, and divides into from two to four granular masses, which, after a varying period of rest, pass out from the capsule and instantly shoot forth pseudopodial rays on all sides, thus assuming the appearance of an *Actinophrys sol.* These Actinophrys-like bodies after a time develop a protoplasmic stalk, or pedicel, by which they attach themselves, usually to the parent capsule. A thin film of protoplasm is then thrown out and subtended by the rays, at a short distance from the body, and this, by development and secretion, becomes the latticed siliceous capsule. The pedicel also becomes more rigid, though always retaining a degree of flexibleness. This manner of reproduction was first described by Cienkowski, the great Russian observer, and discoverer of *Clathrulina elegans* (see Leidy's Rhizopods of North America).

"In the *second* mode of reproduction, the rays are not withdrawn, nor does the body divide, but the sarcode becomes finally vacuolate, presenting knob-like projections. Suddenly a small mass of sarcode, usually one of the knob-like projections, detaches itself, and, passing out of the capsule, shoots out rays and develops, though more slowly, in the manner above described. This continues until the parent body is much reduced in size, when the rays again protrude and the animal returns to its normal condition.

"The *third* mode of reproduction is by the formation and liberation of minute germs. In this state, also, the rays are not withdrawn, but the body of the *Clathrulina* becomes filled with minute green particles, which, even before liberation, exhibit active motion. A number of these are expelled, inclosed in a thin protoplasmic film or globular sac, which bursts shortly, and the liberated germs swim away. The development of these germs, after this point, is yet to be followed.

"The *fourth* mode is still more remarkable, and is also significant in bringing to light a new phase in the life history of the Heliozoa. The *Clathrulina*, in which these phenomena were first observed, withdrew its rays and divided into four parts, as in the ordinary method; but the sarcode, instead of becoming granular and of a rough surface, grew smoother and more transparent. Then followed the period of quiescence; in this case of five or six hours' duration, although in other instances lasting three days and nights; after which one of the four parts began slowly to emerge from the capsule, a second following a few moments later."

For the further progress of the last mode of multiplication, reference must be made to Miss Foulke's own communication. She thinks that "this mode of reproduction secures a more wide-spread distribution of

the young than would be possible did this depend on the sluggish Actinophrys form." (*Proc. Acad. Nat. Sci., Phila.*, 1884, pp. 17–19.)

Infusorians.

A marginal membrane in Trichomonas.—A hitherto unobserved peculiarity of *Trichomonas* has been observed, which should incite to a re-examination of related forms. At the anterior end of *Trichomonas vaginalis* as well as *T. batrachorum*, about the base of the three flagella, T. Blachmann discovered an "undulating membrane" which "extends to about the middle of the body; this membrane, never hitherto observed, may be best seen if the creature is allowed to die gradually."

It is also recorded of *Trichomonas batrachorum* and *Trichomastix lacertæ* at least, that "if the monad is allowed to remain for some time under the pressure of the sun-glass the whole margin of the animal is seen to exhibit an active undulatory movement, though of course this is not so regular as that of the membrane." (*Zeitschr. f. wiss. Zool.*, XL, pp. 42–49; *J. R. M. S.* (2), IV, p. 759.)

PORIFERS.

Sponges.

Fossil sponges.—Although many fossil sponges have been described, the information regarding them has been very scattered and altogether in an unsatisfactory condition. To a large extent this defect has been remedied by the publication of a "Catalogue of the Fossil Sponges in the Geological Department of the British Museum, with descriptions of new and little-known species," by Dr. George J. Hinde. No less than 141 genera were represented by specimens in the Museum; of these 120 contained siliceous sponges, and the rest calcareous. Of the species, 32 belonged to the Palæozoic times, 16 to the Triassic, 96 to the Jurassic, 245 to the Cretaceous, and only 3 were of Tertiary origin. The species have been illustrated by 38 plates.

Some modifications of sponge spicules.—A notable modification of character induced in fresh-water sponges has been encountered by Mr. Edward Potts. This modification has "apparently been affected by the peculiar condition of the environment." Amongst the sponges which Mr. Potts found "encrusting certain old pipes, recently removed, from the water-works in the Schuylkill river in Philadelphia," some portions of the one called *Meyenia Leidyi* were "much more deeply colored with rust than others, the statoblasts, particularly, seeming to be mere pseudomorphs of their originals in iron oxide. Fragments of this character were boiled in nitric acid, washed out and mounted for comparison with other matter similarly treated, but free from such discoloration." "The normal skeleton spicule of the *Meyenia Leidyi* is "smooth, robust and shorter than that of any other American species. Very rarely the fine line of the axial channel is visible, but in the specimen under examin-

ation the size and exterior appearance of the spiculæ remaining as before, the hardly noticeable channel has become a wide canal, open at both ends, and occupying more than one-half of the breadth of the spicule. This does not occur merely in occasional instances, but universally throughout the fragment of sponge so affected.

"The birotulate spicules of this sponge also are short and of a peculiarly substantial appearance, with entire reflexed margins, yet in the present preparation they could with difficulty be detected as mere ghosts of their normal shapes. The two discs rarely remained together, their characteristic entire margins were gone, the rotules being represented merely by a line of very fine rays." (*Proc. Acad. Nat. Sc. Phila.*, 1884, pp. 184–185.)

Fresh-water sponges and water pollution.—It has been stated that fresh-water sponges, in their decay, are a notable source of pollution of drinking-water, and that the supply thereof derived from the reservoirs may be materially injured by them. Mr. Edward Potts has taken measures to inquire into the truth of these allegations. In the month of February, 1884, he examined "the fore-bay at Fairmount Waterworks, on the Schuylkill River", when the water had been temporarily withdrawn. He found, on the bottom and sides, wherever he could get within reach, and as far as his eye could detect in other places, the surface "covered by a mud-colored incrustation of considerable thickness, which a more minute examination showed to be composed almost wholly of statoblasts and spicules of the sponge *Meyenia Leidyi*," which was the prominent one. Some few remains of *Meyenia fluviatilis* and *Spongilla fragilis* were also seen.

"While considering the effect of the presence of so large a sponge growth at the very inlet to the supply pumps, Mr. Potts stated that this particular species was conspicuous among the known North American sponges by its great relative density and the small proportion of its sarcode or flesh. Its decay, therefore, at the termination of its period of summer growth would be a less cause of pollution to the water-supply than that of any other sponge.

"Moreover, from recent investigations into the life history of these low organisms, he was inclined to believe that decay was not the normal or necessary result of the close of each season's growth. The fragile branches of some species inhabiting exposed situations may, of course, be broken off and destroyed while the sarcode still covers them; but in the sessile portions, and in all when sufficiently protected, the cells of the sarcode at the period of full maturity, forsaking their places along the lines of the skeleton framework, gather together by simultaneous amæboid movements into dense groups, where they are soon covered by a tough chitinous 'coat,' which, in time, generally becomes surrounded by a 'crust' of minute granular cells, and armor-plated by a series of protective spicules. These groups are now recognized as the statoblasts, gemmules or winter eggs of the sponge—eggs only in

appearance—in reality the resting spores or protected germs which conserve the life of the individual through the cold and storms of winter, and awake very early in the spring-time into new life, yet a continuance only of the same existence which was seen a few months before nestling into this winter's sleep.

"If this is the ordinary course with these organisms there seems no reason to regard them as serious causes of the pollution of our streams, though violent freshets before this resting period is reached may tear them to pieces, and their decay may give a temporary taint to the water." (*Proc. Acad. Nat. Sc., Phila.*, 1884, pp. 28–30.)

CŒLENTERATES.

Polyps.

Variation in corals.—The Astrangiacea (Madreporaria) have been studied by Mr. S. O. Ridley, and have been found to present striking individual variations in characters which have been assumed to be constant and employed for the definition of generic or supergeneric groups. Such variations affect the columella, costæ, and paliform lobes, and characters depending on their modifications must be employed with great caution in the study of the Astrangiacea, "whatever may be the value for classification of the corresponding parts in the Turbinoliidæ and Oculinidæ." (*Journ. Linn. Soc. London, Zool.*, XVII, pp. 395–399, 1 pl.; *J. R. M. S.* (2) V, p. 73.)

Acalephs.

The hydriform stage of Limnicodium.—Notices have been published in previous issues of these records of progress in zoology, of the remarkable little fresh-water Medusa, named *Limnicodium Sowerbii*, in the Victoria tank of the Royal Botanic Gardens in Regent's Park, London. About four years and a half had elapsed since the discovery of the mature form before the hydriform stage was discovered, although assiduous search had been made for it. But, on the occasion of the clearing out of the tank in December, 1884, more than usual thorough search was instituted, and this was at length rewarded by the finding of the hydra on some *Pontederiæ* imported from South America several years ago. Professor Lankester immediately communicated a notice of the discovery to the London *Times* and Mr. A. G. Bourne (who first detected it) to *Nature* (v. 31, p. 107, December 4, 1884). The details were not published in 1884.

ECHINODERMS.

Origin of Echinoderms.

The development of the germinal layers of Echinoderms has been studied by Prof. E. Selenka. The cleavage of the egg is said in general terms to be regular, but really "pseudo-regular" in the Asterioids or

star-fishes and Ophiuroids, and "regular with polar differentiation" in the Echinoids. "The various modes of cleavage are of no value for the phylogenetic history of the group; the influence of cenogeny is apparent enough." For further and explanatory details the memoir of Professor Selenka must be consulted, but his conclusions as to the genetic relations of the group are of sufficient general interest to warrant repeating here: "Evidence of the vermian origin of Echinoderms is afforded by the primary mesoderm having the form of two primitive cells and by the bilateral symmetry of the larval organs. The division of the archenteric diverticulum into codomic sac and water-vessels correspond physiologically to that which the mesodermic sac undergoes in vertebrates, and to some extent in worms." (*Selenka's Studien über Entwickelungsgeschichte*, II; *J. R. M. S.* (2), IV, pp. 573–574.)

Crinoids.

Reproductive function in Comatula.—Interesting observations have recently been made on the actions and apparent copulation of two individuals of the *Comatula meditteranea* by Dr. C. F. Jickeli. The phenomenon resembled that previously noticed in a star-fish (*Asterina gibbosa*) by Dr. H. Ludwig. The arms fell off as a climax, and this appeared to confirm Studer's supposition that the loss of the arms, which often occurs in star fishes, is connected with the discharge of the sexual products. (*Zool. Anzeiger*, VII, pp. 444–449; *Ann. & Mag. Nat. Hist.* (6), XIV, pp. 367–368; *J. R. M. S.* (2), V, pp. 70–71.)

Asterioids.

A deep-sea star-fish.—An interesting star-fish, obtained in Faeroe Channel, at a depth of 555 fathoms, has been described by Mr. W. Percy Sladen, under the name *Mimaster Tizardi*. Its interest arises from the bonds of union with several quite diverse types, and it is indeed what used to be called a synthetic or comprehensive type. It recalls in different parts some Asteriidæ (*Solaster*), Astropectinidæ, Goniasteridæ, and Asterinidæ. It appears to be nearly related to a genus also lately described, called *Radiaster*. (*Trans. Royal Soc. Edinb.*, XXX, pp. 579–584, 1 pl.; *J. R. M. S.* (2), IV p. 903.)

Echinoids.

Morphology of the Echinoids.—In connection with studies of the Echinoids, and especially of the deep-sea species constituting the family Pourtalesiidæ, Prof. S. Loven has considered the general characters of the order. The skeleton is "a hollow sac inclosing the visceral organs, and constituted by three distinct systems—ambulacral, perisomatic or interradial, and calycinal or apical." On a careful study of this skeleton, it is found that "its constituent elements are in reality and fundamentally arranged bilaterally and symmetrically on either side of the mesial

plane, indicated by its antero-posterior axis. The archæonomous or old-fashioned type of the Clypeastridæ as well as the neonomous or new-fashioned Spatangidæ give distinct indications of the bilateral form of the adult. Though more difficult to detect, this bilaterality obtains also in the ancient Cidaridæ, and we have here "another instance of the validity of the laws more than once ascertained to underlie evolution, namely, that structures which are gradually but forcibly worked out during the course of geological ages into specialized and highly characteristic features are virtually present within the fabric of the earlier forms, though dormant, and, as it were, lying in abeyance, and to be detected only by a close scrutiny."

In another place, in a discussion of the "calycinal system" (which is defined as consisting of a central ossicle, five costals, and five radials), Professor Loven speculates on the evolution of certain forms and parts. "*Tiarechinus*, with its enormous calyx, appears to be the most antique of Echinoids. While a number of forms retain a stable relation of the parts, we find that, when this is disturbed, the anal orifice is the first to alter its position; it is followed by the madreporic and generative parts, but the eyes remain stationary," &c.

The manner in which changes may take place are summarized by the author in the following terms: "A large and powerful structure, closely specialized for a function of fundamental importance in the economy of some remote ancestral type, is inherited in an early state by a descendant in which, from a total change in the mode of life, the very purpose no longer exists for which it was originally contrived and to which its parts were adapted. It long retains certain marked features which even to this day reveal its origin, but, unlike its Crinoidean sister-structure which, with functions unaltered, multiplies its components, it remains simple as from the beginning, and superfluous as it has become, gradually declines in intrinsic vigor, and is given up to subserving activities that had no share in its previous existence. Invaded by contending organs and yielding to their various tendencies, it has its parts deeply modified and even to some degree suppressed, and although still true to its type, and asserting, so to say, its unimpaired independence by redintegrating its injured frame, it dwindles, nevertheless, from age to age in every succeeding form and is seen to fall into decay and dismemberment and to lose one by one its characteristics, till at last little remains of its original constitution." (*K. Svenska Vet. Akad. Handl.*, XIX, 95 pp., pl. 21; *J. R. M. S.* (2), IV, pp. 751–754.)

Holothurians.

A large Holothurian.—The pharynx of a very large Holothurian, dredged up in the Sulu Sea, has been described by Prof. H. N. Moseley. No traces of the rest of the animal were found, but the pharynx exhibits unusual characters and the calcareous skeleton is remarkably developed. It is, however, most noteworthy here on account of its large size, being

.$\frac{3}{8}$ inches long, thus exceeding in size the corresponding part of any other species and indicating the existence of a Holothurian larger than any previously known. (*Quart. Journ. Mic. Sc.*, XXIV, pp. 255–261, with pl.)

WORMS.

Rotifers.

Classification of Rotifers.—A new classification of the Rotifers has been proposed by Dr. C. T. Hudson, who, it is understood, has been for some time engaged in company with Mr. H. P. Gosse on a monograph of the class. Twelve families are recognized and defined, and these are segregated under four groups called "orders" and distinguished chiefly by the mode of progression. At first sight this might seem to be an unsafe guide, and it remains to be seen whether it will stand the test of critical analysis. The ordinal characters and families are as follows:

"ORDER I, RHIZOTA," including fixed forms, with the foot attached, transversely wrinkled, non-retractile, and truncate.

Family 1, Flosculariidæ.

Family 2, Melicertidæ.

"ORDER II, BDELLOIDA," including Rotifers "that swim and creep like a leech," with the "foot retractile, jointed, telescopic," and with its "termination furcate."

Family 3, Philodinidæ.

"ORDER III, PLOIMA," composed of Rotifers "that only swim."

Illoricated.

Family 4, Hydatinidæ.

Family 5, Synchætidæ.

Family 6, Notommatidæ.

Family 7, Triarthridæ.

Family 8, Asplanchnidæ.

Loricated.

Family 9, Brachionidæ.

Family 10, Pterodinidæ.

Family 11, Euchlanidæ.

"ORDER IV, SCIRTOPODA," embracing "Rotifers that swim with their ciliary wreath, and skip by means of hollow limbs with internal locomotor muscles.

Family 12, Pedalionidæ."

(*Quart. Journ. Mic. Sc.*, XXIV, pp. 335–356; *J. R. M. S.* (2), IV, pp. 748–750.)

Platyhelminths.

Free-living Nematoids.—The free-living fresh-water Nematoids of the Dutch fauna have been investigated by Mr. J. G. de Man, conservator of the zoological museum of Leyden, and the results published in a spe-

cial monograph. These worms are not easily found; to obtain them, it is necessary to dig with a knife into moist ground, and especially to seek for them about the roots of trees. The fresh-water species are generally found among the leaves of plants, filaments of algæ, or confervæ, while others are met with in the muddy bottoms of ponds and brooks.

A rare human Tapeworm.—At least eight species of tapeworms or intestinal worms of the family *Tæniidæ* have been found in the human body in varying numbers. Of course, the most common are the *Tænia solium* and the *Tænia mediocanellata*, the former being derived ordinarily from pork, and the latter from beef. There is one species of the family—the *Tænia (Hymenolepis) flavopunctata*—that has only once been found in the intestines of man. It was in 1858 that Dr. Weinland discovered some specimens discharged by a child in Boston. Dr. Leidy recently obtained evidences of the same species expelled from a child three years old by a dose of santonin; the specimens, consisting of a dozen fragments, appeared to be portions of three worms, which reached a length of from twelve to fifteen inches or more. Unfortunately the head was lost, but enough remained to identify the species. "The mature eggs are spherical, measure some 0.072 millimeter in diameter, and contain, fully developed, six hooked embryos."

Although so rarely met with, it was thought by Dr. Leidy to be probable that the worm is more common than would be supposed from the rare instances of its observation, and that it has generally escaped notice only "from its small size, and from the general ignorance of the distinction, not only of this, but of the ordinary species of tapeworms." Nothing is known respecting the life history of the worm or its other hosts. (*Proc. Acad. Nat. Sc. Phila.*, 1884, p. 137.)

Nematelminths.

The origin of the eggs and sperm of Ascaris.—The direction of the studies of zoologists nowadays is well illustrated by several very elaborate memoirs on the genesis of the eggs and sperm in the common intestinal thread-worm of the horse (*Ascaris megalocephala*). One by Dr. E. Van Beneden on the ovum and its fertilization takes up 375 pages; another, by Van Beneden and Julin, on the spermatogenesis, is 30 pages long; and another, also on the spermatogenesis, by Dr. P. Hallez, is 3 pages long. The most important of these memoirs is published in the Archives de Biologie (IV, pp. 265–640, with 1 pl.).

Annelids.

An American fresh-water Worm.—In certain rivers of Eastern America, beyond the inflow of salt or brackish water, is found a species of tube-making chætobranch worm which is closely related to certain sea-worms, and which has no known relation in fresh waters elsewhere.

This was first described by the great American naturalist, Dr. Leidy, and has recently been the subject of renewed examination by two other naturalists of Philadelphia, Miss Sara G. Foulke and Mr. Edward Potts.

The tentacular crown, or branchial organ, is considered by Miss Foulke to be the feature of special interest.

"According to Dr. Leidy, the tentacles present in an adult are eighteen in number, besides two larger and longer tentacles situated midway between the two lophophores. These larger tentacles are conspicuous by their bright green color, and are, in fact, external continuations of the blood-vessels extending lengthwise throughout the body. In shape these tentacles taper from base to apex; are convex on the outside, but concave on the side which faces the center of the tentacular crown, so that a transverse section would present the shape of a crescent. The two edges thus formed are fringed with cilia. When closely watched, the green tentacles are seen to pulsate with a rhythmical motion, contracting and expanding longitudinally. The pulsation takes place in each tentacle alternately.

"At the moment of contraction the tentacle turns slightly on its axis, outwards and towards the end of the lophophore on that side, at the same time giving a backward jerk, returning to its former position at the moment of expansion.

"By force of the contraction, the green blood filling the tentacle is forced downward out of the tentacle, and flows along the blood-vessel on that side of the body. On the expanding of the tentacle, the blood instantly returns and suffuses it, and thus the process goes on."

Mr. Potts's observations were chiefly devoted to the manner in which the worm takes its food.

Although the crown of the tentacles imparts to the worms some resemblance to a polyzoan, "there is a noticeable difference in the effect produced by the motion of their cilia. In the latter a powerful *incurrent* bears food particles, &c., towards the mouth as a vortex; in the former case, while the motion draws these particles from without or behind the circle towards the tentacles, the moment they pass between them they are influenced by an *excurrent* bearing them forcibly away. This outflowing current is further shown by the fact that excrementitious matters are drawn rapidly forward through the tube, and ejected at its anterior extremity.

"As food, therefore, cannot be *sucked* into the mouth of the worm, we find that it is *carried* in. Acceptable particles which touch the tentacles are grasped by the cilia, and rapidly passed down among them in near contact with the tentacle into grooves at the base of the above-mentioned processes, and thence into the digestive tract."

Mr. Potts was also fortunate enough to be able to study the worm in the act of building a tube.

In its earliest stages, the tube "is a transparent, smooth, and homogeneous slime-like excretion, within which the worm may be very clearly

seen, as it works its way forward or drags itself backward by means of its podal hooks and spines. Later on, the anterior extremity thickens and becomes more and more opaque, and, as Dr. Leidy has observed, 'feebly annulated,' presumably from the adherence of effete particles, and their compression by the repeated withdrawal of the ciliated tentacles into the mouth of the tube. This method of prolongation must continue during the residence of the worm, and in consequence, if supported, it may sometimes reach a length which is several times that of its inhabitant." (*Proc. Acad. Nat. Sc. Phila.*, 1884, pp. 48, 49, 21, 22.)

Earth-worms in New Zealand.—The extensive modifications which the boring and concomitant habits of earth-worms effect upon the land, have become familiar through the work of Darwin on those humble animals. The surprising results effected by worms on ordinary English land might be made, according to the estimate of Darwin, by an army consisting of an average of about 26,886 to the acre. Later, Henson, from observations conducted in Germany, estimated that in favorable localities about twice as many as were calculated for by Darwin (53,767) existed in garden grounds, while in green fields the number would closely approximate that presented by the great English naturalist. The abundance of a New Zealand species has recently been brought to light, and Mr. A. T. Urquhart gives, as the result of his investigations, to an acre of pasture land near Auckland, the large number of 348,480 worms as found therein; and on his results being challenged, even this number was greatly increased by subsequent experience. A piece was "laid out into squares of 120 feet, and a square foot of soil was taken out at each corner; worms hanging to the side walls of the holes were not counted, and in one hole, where the return of worms was a blank, the walls were crowded with worms." As the result, there was an average of 18 worms per square foot, or 784,080 worms per acre. Although this average is in number so striking, when compared with those of Darwin and Henson, the difference between the actual weight of the worms is very much less in proportion. "According to Henson, his average of 53,767 worms would weigh 356 pounds, while Mr. Urquhart finds that the average weight of the number found by him came to 612 pounds 9 ounces," or less than twice the aggregate of the German percentage. The value of the observations on the New Zealand worms would have been much enhanced had their relationship been determined. (*Trans. New Zealand Inst.*, v. 26; *Nature*, v. 31, p. 23.)

Myzostomids.

The species of Myzostomids.—More than forty years ago Prof. F. S. Leuckart discovered certain singular organisms parasitic on the arms of the crinoid known as *Antedon rosacea*, which were recognized as two species of a previously unknown type, and which received from him the generic name *Myzostoma;* one of the species was called *M. glabrum* and

the other *M. cirriferum.* The relations of this type to other animals have been involved in doubt, and various discrepant opinions have been entertained respecting its proper systematic position.

The Myzostomids are minute disk-like animals, sometimes almost perfectly round and with markings recalling the marks on the face of a watch. They are parasitic on Crinoids. The question of their relationships has recently been discussed by Dr. L. von Graff and Dr. J. Beard.

Dr. von Graff thinks that they are related to the Tardigrades, and indeed proposes to take that group, as well as the Linguatuloids, from the Arachnids and combine them with the Myzostomids in a special class, which he names Stelechopoda.

Dr. Beard had the opportunity to study the embryology of the type and has been led to consider them as chætopod worms which have become degenerate through parasitism.

The collections of the Challenger expedition of Crinoids were examined for these parasites, and a large number of new species were thus obtained. Of sixty-eight species detected on the Challenger Crinoids, fifty-two were new, and one of these was the type of a very peculiar family named Stelechopodidæ. (*Rep. Voyage Challenger, Zool.*, v. 10; *Nature*, v. 31, pp. 165, 166; *Mitth. Zool. Stat. Neapel*, v. 5, pp. 544–580, 2 pl.; *J. R. M. S.* (2), v. 5, pp. 66–69.)

ARTHROPODS.

Crustaceans.

The stomach of stalk-eyed Crustaceans.—The stomach of the podophthalmous or stalk-eyed Crustaceans and its approaches exhibit some interesting features, and especially in the armature by the stone-like grinding pieces. The entire subject has been made the theme of study by M. F. Mocquard, and his investigations have not been limited to the stomachal armature, but have extended likewise to the muscles as well as the nerves. In every natural family, according to M. Mocquard, the stomachal apparatus is, as a rule, disposed on some special plan which is typical for each of them. There is, in the first place, a distinction which is quite trenchant between the brachyurous and macrurous Crustaceans. In the former, there is a narrow triangular mesocardiac piece, and elongated horizontal pterocardiac ones, but in the latter, the mesocardiac piece is very wide and the pterocardiac ones short and almost vertical. The anomurans show, in this apparatus, the heterogeneous character of the group, for some are like the macrurans and others like the brachyurans. In the brachyurans, the gastric skeleton, with but few exceptions, is quite uniform, but in the macrurans there is great diversity. The various modifications are of systematic importance, and in many cases may give essential help in determining the relations of the various forms. As an instance, one of the results reached by M. Mocquard may be noticed. Ocypodidæ are divided into

two groups, one restricted to the "Ocypodiacea," and the other comprising the Gelasimi and related genera as well as the Pinnotherians. Whether such a combination is natural may be questioned, but a renewed examination of the detailed structure of the several types may be demanded as the result of the investigation.

The muscles of the stomach and its armature are described in considerable detail, both in respect to their connections and functions. The median tooth is advanced forward and the two lateral pieces are approximated at their anterior extremities. The median tooth is lodged in an angle between the lateral, and all together are worked for a second to grind the food taken in, then there is relaxation, and then again a new contraction, and so on. The urocardiac piece serves to maintain the food in the special region. M. Mocquard thinks that these movements are not reflex, but voluntary, as Cuvier had already contended.

The muscles which work the gastric pieces are innervated by nerves issuing from the stomatogastric. The functions of this are analogous to those of the sympathetic nerve, and are complex; in one place it is subservient to sensation and involuntary movements, and it also regulates voluntary movement as of the labrum and œsophagus; perhaps even it has filaments of special sensibility. Several questions of this kind are left in doubt, and M. Mocquard disclaims having exhausted the subject. (*Revue Scientifique*, t. XXXIV, pp. 204, 205.)

Peculiarities of deep-sea Crustaceans.—In a summary of the "Crustacea of the Albatross dredgings in 1883," Prof. Sidney I. Smith has enunciated some generalities respecting the characteristics of the deep-sea crustaceans. A striking characteristic is their red or reddish color. "A few species are apparently nearly colorless, but the great majority are some shade of red or orange," and he had met with "no evidence of any other bright color." A few species "from between 100 and 300 fathoms are conspicuously marked with scarlet or vermilion, but such brighter markings were not noticed in any species from below 1,000 fathoms. Below this depth, orange red of varying intensity, is apparently the most common color, although in several species the color was an excessively intense dark crimson."

The eyes of the abyssal species are even more remarkable than their colors. In sixteen species especially examined, the eyes were present in the normal position, and distinctly faceted. In six they were well developed, but smaller than in average prawns, and of a black color. In one the eyes were "black, but conspicuously smaller than in the allied shallow-water species." In another they were "black, and of moderate size"; and in still another they were "apparently black, or nearly black, and small." In one they were "nearly colorless in alcoholic specimens, and rather larger than usual in the genus, but considerably smaller" than in related species found at less depth. In three they were "not conspicuously different in size from those of allied shal-

low-water species, and are dark brown." Professor Smith, from these data, concludes that, "however strong may be the arguments of the physicists against the possibility of any light penetrating the depths from which these animals come, the color and strength of their eyes, as compared with blind cave-dwelling species, show conclusively that the depth beneath 2,000 fathoms of sea-water is very different from that of ordinary caverns. While it may be possible that this modification of the darkness of the ocean abysses is due to phosphorescence of the animals themselves, it does not seem probable that it is wholly due to this cause."

Another feature characteristic of the deep-sea crustaceans is the large size of the eggs, which becomes a very marked feature in many of the deep water-decapods. The largest crustacean eggs known to Professor Smith are those of "*Parapasiphaë sulcatifrons*, a slender shrimp, less than three inches long, taken between 1,000 and 3,000 fathoms. Alcoholic specimens of these eggs are fully 4 or 5 millimeters in shorter and longer diameter, fully ten times the volume of the eggs of *Pasiphaë tarda* from 100 to 200 fathoms, more than three hundred and fifty times the volume of those of a larger shallow-water *Palæmon*, and each one more than a hundredth of the volume of the largest individual of the species." Professor Smith concludes that "from the peculiar environment of deep-water species, it seems probable that many of them pass through an abbreviated metamorphosis within the egg, like many fresh-water and terrestrial species, and these large eggs are apparently adapted to producing young of large size, in an advanced stage of development, and specially fitted to live under conditions similar to those environing the adults."

These conclusions of Professor Smith appear to be highly probable, and are consonant with the facts observed in fishes. In those forms of the class which do not take any care of their eggs, the number of eggs is extremely large, while in those which guard the eggs or young, they are very much reduced in number but increased in size. (*Am. Jour. Sc.*, (3), v. 28, pp. 53–56.)

Arachnids.

An ancient Scorpion.—The oldest of the scorpions until lately known were inhabitants of the earth in the Carboniferous epoch. Two of the four described types were the results of American investigations; but during the past year several examples of a species were obtained from Upper Silurian rocks in Europe. One specimen was found by Prof. Gustav Lindström, in the Swedish island of Gothland. It was in a good condition of preservation and showed the "chitinous brown or yellowish brown cuticle, very thin, compressed and corrugated by the pressure of the superposed layers." The different segments, "the cephalothorax, the abdomen, with seven dorsal laminæ, and the tail, consisting of six segments or rings, the last narrowing and sloping into the venomous dart,"

could all be distinguished. The surface of the back was sculptured by tubercles and longitudinal keels corresponding with those developed in recent species. "One of the stigmata on the right is visible, and clearly demonstrates that it must have belonged to an air-breathing animal, and the whole organization indicates that it lived on dry land." "In the conformation of this scorpion there is one feature of great importance, namely, four pairs of thoracic feet, large and pointed, resembling the feet of the embryos of several other tracheates and animals like the Campodea. This form of feet no longer exists in the fossil scorpions of the Carboniferous formation, the appendices belonging to which resemble those found in the scorpions of our own day." The form in question was named by Professor Lindström *Palæophoneus nuncius*, and is "the most ancient" of all known "land-animals."

Some time before the description by Professor Lindström of this new animal was published, Dr. Hunter, of Carluke, obtained a fossil scorpion also from the Upper Silurian, but in Scottish Lanarkshire, in June, 1883. It was not, however, until Professor Lindström's description of the Swedish find appeared that Dr. Hunter recognized the importance of his own discovery. "The rocks from which the Scottish example was obtained are the well-known Upper Silurian beds of Dunside, Logan Water, Lesmahagow, Lanarkshire, which have yielded such a magnificent suite of Eurypterids, and supplied a great part of the materials for Dr. Woodward's work on the Merostomata. The animal in this specimen is about an inch and a half long, and lies on its back on the stone. Its exposed ventral surface shows almost every external organ that can be seen in that position, and in this way seems to supplement the evidence supplied by the Swedish specimen. As in the northern individual, the first and second pairs of appendages of the cephalothorax in the Scottish example are chelate, but the palpi are not quite so robust. The walking-limbs, though not so dumpy as in *P. nuncius*, also terminate each in a single claw-like spike. The arrangement of the sternum shows a large pentagonal plate (metasternite) against which the wedge-shaped coxæ of the fourth pair of walking-limbs abut. The coxæ of the third pair bound the pentagonal plate along its upper margins, and meet in the mid-line of the body, where they are firmly united. The coxæ of the first two pairs, as well as the bases of the palpi, are drawn aside from the center line of the body, showing that, as in recent scorpions, these alone were concerned in manducation, or rather the squeezing out of the juices of the prey. From the circumstance of these being drawn aside, the medial eyes are seen pressed up through the cuticle of the gullet, and a fleshy labrum (camerostome) appears between the bases of the chelicerae."

The characteristics exhibited by these very old scorpions are such as to separate them quite widely from any of the recent types, and although evidently belonging to the same order, and thus related to the latter, they indicate a peculiar family, the Palæophoneidæ. Doubtless renewed

searching for fossils in the Silurian rocks, and especially for terrestrial types, will be prosecuted, for such discoveries will serve as very efficient stimulants. (*Nature*, v. 31, pp. 295–298.)

Curious mimicry by a Spider.—A curious case of mimicry by a spider has been recorded by Mr. H. O. Forbes. The spider in question is found in Sumatra, and has been named *Thomisus decipiens*. On June 25, 1885, in a forest of Sumatra, Mr. Forbes' attention was excited by his "eyes resting on a bird-excreta-marked leaf." On examination it was found that the appearance was deceptive and had been produced by a spider which had so closely copied nature that the imitation would readily deceive the uncritical observer. "The spider is in general color white, spotted here and there with black; on the under side its rather irregularly shaped and prominent abdomen is almost all white—of a pure chalk white; the angles of the legs are, however, shining jet black. The spider does not make an ordinary web, but only the thinnest film on the surface of the leaf. The appearance of the excreta rather recently left by a bird on a leaf is well known. There is a pure white deposit in the center, thinning out round the margin, while in the central mass are dark portions variously disposed; as the leaf is rarely horizontal, the more liquid portions run for some distance. Now, this spider, one might almost imagine to have in its rambles marked and inwardly discerned what it had observed, and had set about practicing the wrinkles gained; for it first weaves a small irregular patch of white web on some prominent leaf, then a narrow streak laid down towards its sloping margin, ending in a small knob. It then takes its place on the center of the irregular spot on its back, crosses its black-angled legs over its thorax and waits. Its pure white abdomen represents the central mass of the bird's excreta, the black legs the dark portions of the slime, while the web above described represents the more watery marginal part (become dry), even to the run-off portion with the thickened knob (which was not accidental, as it occurred in both cases), like the residue which semi-fluid substances, ending in a drop, leave on evaporation. It keeps itself in position on its back by thrusting under the web below it the spines with which the anterior upper surface of the legs is furnished."

The most interesting fact of all, in the opinion of Mr. Forbes, is "not so much that of the spider having gained, which it can, of course, have no consciousness of, by natural selection, the color and form of an excretum, but that it has acquired the habit of supplementing its own color and form by an addition in such absolute harmony with that of which itself is the similitude."

This species, on being re-examined by the Rev. O. P. Cambridge, the distinguished arachnologist, was considered to represent a peculiar genus which was named *Ornithoscatoides*, from its simulation of a bird's excreta. Further, Mr. Cambridge recognized in various collections

four species of the genus, all of which inhabit India and the neighboring islands. It seemed to Mr. Cambridge that the whole phenomenon described is "easily explained by the operation of natural selection, without supposing consciousness in the spider in any part of the process. The web on the surface of the leaf is evidently, so far as the spider has any design or consciousness in the matter, spun simply to secure itself in the proper position to await and seize its prey. The silk, which by its fineness, whiteness, and close adhesion to the leaf causes it to resemble the more fluid parts of the excreta, would gradually attain those qualities by natural selection, just as the spider itself would gradually, and probably *pari passu*, become under the influence of the same law, more and more like the solid portion." (*Proc. Zool. Soc. London*, 1883, pp. 586–588, pl. 51; 1884, p. 196–203, pl. 15.)

Insects.

The mouth parts of suctorial Insects.—In connection with a memoir on the systematic position of the *Pulicidæ*, Dr. Karl Kräpelin has discussed the structure of the mouth parts not only of the Fleas, but of the forms with which they have been associated by other authors, the Diptera and Hemiptera, and the results are of considerable systematic importance. It is found that the suctorial insects segregate themselves into two primary groups. In one, consisting of the Hymenoptera and Lepidoptera, the suctorial organs are characterized by the lower parts of the mouth, maxillæ and labium, being employed in the formation of a sucking apparatus, while in another group, represented by the Diptera, Siphonaptera, and Rhynchota, it is almost exclusively the upper parts, labium and mandibles, that are implicated in the formation of the true food canal. The characteristics of the mouth parts of the three orders of the latter section are thus diagnosed by Dr. Kräpelin:

(1) *Diptera.*—"Insects with perfect metamorphosis. Head free, with facetted eyes. Sucking-tube formed by a dorsal and a ventral half-channel (labrum and hypopharynx), more or less inclosed throughout its length by the labium, which is bent up like a sheath, and furnished with uniarticulate apical palpi. Mandibles deficient or styletiform, pushing in between the labrum and hypopharynx. Maxillæ, when present, with palpi. Salivary efferent duct an unpaired closed canal in the interior of the hypopharynx. A 'sucking-stomach.' Thoracic segments amalgamated, usually with a pair of wings and a pair of halteres."

(2) *Siphonaptera.*—"Insects with perfect metamorphosis. Head attached to the thorax by a wide surface, without facetted eyes. Buccal organs suctorial. Sucking-tube formed by a dorsal and two lateral channels (labrum and mandibles), its anterior section only more or less inclosed laterally by the mulitiarticulate terminal palpi of the labium, and at the base, besides the latter, by the lamelliform palpigerous maxillæ. Salivary efferent ducts paired, developed as a channel along the inner surface of the mandibles. No 'sucking-stomach.' Thoracic seg-

ments free, without wings and halteres, with pleural processes upon the last two segments."

(3) *Rynchota.*—"Insect usually with imperfect metamorphosis. Head free or broadly united to the thorax, with or without facetted eyes. Buccal organs usually suctorial. Sucking-tube (in the higher groups) composed of two lateral half-channels (the mandibles), only in the anterior portion inclosed by the labium and its apical multiarticulate palpi, which are united nearly to the apex; at the base by the labrum. Maxillæ styliform, without palpi, applied laterally to the mandibles in the channel of the labium or the labrum. Salivary efferent duct unpaired, formed by two half-channels of the mandibles closing together from the sides. No 'sucking-stomach.' Thoracic segments free or amalgamated. Four, two, or no wings; no halteres."

Relations of the Embioid Insects.—In a contribution to our knowledge of the *Embiidæ*, a family of Orthopterous insects, Mr. J. Wood-Mason has added to our knowledge by describing the various phases of development of some *Embiidæ*, and expresses his opinion as to the relations of those curious insects. The *Embiidæ*, he thinks, "undoubtedly belong to the true Orthoptera," but they are "in some respects the lowest term, and in others the lowest term but one, of a series represented by the families *Acridioidea*, *Locustidæ*, *Gryllidæ*, and *Phasmatidæ;*" their "resemblances to the much lower *Perlidæ*, which may well be direct descendants of a form closely related to *Campodea*, are due to their low position in the division of Orthopterous insects to which they belong, and do not imply any such close genetic relationship to them as has been suggested." (*Proc. Zool. Soc. London*, 1883, pp. 628–634, pl. 56.)

MOLLUSCOIDS.

Polyzoans.

Morphology of Flustra.—The investigation of the marine Bryozoans has been undertaken by W. J. Vigelius, who proposes to publish a monograph on the subject. A treatise on the morphology of *Flustra membranaceo-truncata* is a precursor of and an introduction to the work. The *Flustræ* corroborate the dictum that the mode of growth of the Bryozoan stock is of no value as a means of distinguishing families, for which it has often been used. The nutrient animal and the avicularium are alone distinctly differentiated individuals, for the brood-capsules are simply organs. The nutrient animals may be (1) budding, found on the marginal zone of the colony; (2) perfect or reproductive forms; (3) resting; and (4) decaying. The last two are only found near the proximal part of the stock, and are much rarer than the others. "The cystid and polypid make up the complete nutrient animal, and in the normal condition consist of integument, nutrient apparatus, and parenchymatous tissue." No nervous system has been distinctly

recognized, but it is supposed that "its center is perhaps represented by the small rounded mass of cells which lies on the anal side of the anterior wall of the pharynx." Spermatoblasts are "derived from the repeated subdivision of the spermatophores, but they do not form rounded or oval masses of regularly arranged cells placed on a nutrient blastophore"; when they become converted into spermatozoa they are at first pyriform, and only later does the tail arise at the narrow end and become of some length. The histolysis of the digestive tract was investigated, and to the brown body is attributed a nutrient function. The cystid and polypid are parts of a single individual, as is proved by the history of the process of germination as well as by the organization of the complete nutrient animal.

The perigastric space is regarded as a true cœlon, but the polyzoa are claimed to be pseudo-cœlia. (*Biol. Centralblatt*, III, pp. 705–721; *J. R. M. S.* (2), IV, p. 371.)

Brachiopods.

Anatomy of Argiope.—Several species of *Argiope* have been dissected and studied within the last two years by Dr. A. E. Shipley and Dr. A. Schulgin, the former having worked at Naples on the *A. Neapolitana* and *A. cuneata*, and the latter on the *A. Kowalevskii.* The brachial appendages, to which in typical Terebratulids the gills are attached, are wanting in *Argiope.* There is, according to Schulgin, a feebly developed subœsophageal ganglion overlooked by Shipley, who mistook the external sensory for the central nervous system.

The relationships of the Brachiopods are considered by both authors. Dr. Shipley accepted essentially the views of Professor Gegenbaur. (See S. I. Report for 1883.) Dr. Schulgin thought it "probable that the Polyzoa and Brachiopoda arose from a side branch or phylum, which also gave rise to Annelids," and they may be "grouped together under the class of Vermoidea." (*Zeitschr. f. Wis. Zool.*, v. 41, pp. 116–141, 2 pl.; *J. R. M. S.* (2), v. 5, pp. 49, 50.)

MOLLUSKS.

Acephals.

A new Classification of Bivalve Shells.—Much dissatisfaction has been expressed with all the current arrangements of the Acephals, or bivalve mollusks, and Dr. M. Neumayr has proposed a new one which he thinks has some advantages compared with the others. The shells are considered from a palæontological point of view, and the data derived from palæontology being co-ordinated with those obtained from a study of the hinge of the shell, Dr. Neumayr was led to segregate all the known forms into three orders, all differing from those of his predecessors, and to which he has given new names. The definitions of the groups, as rendered in English by Dr. von Martens, are as follows:

"Ord. 1. PALÆOCONCHÆ, or *Cryptodonta.* Shell thin, without teeth,

or only with feeble indications of them in the hinge; two equal muscular impressions; pallial line entire. Palæozoic.

"Ord. 2. DESMODONATA. Teeth of the hinge none or irregular, connected with the ligamental processes; two equal muscular impressions; pallial line sinuated. *Pholadomyidæ, Corbulidæ, Myidæ, Anatinidæ, Mactridæ, Paphiidæ, Glycymeridæ,* (?) *Solenidæ,* and all *Tubicola.*

"Ord. 3. TAXODONTA. Teeth of the hinge numerous, not differentiated, in a straight, arcuated or angular row; two equal muscular impressions. *Arcidæ, Nuculidæ.*

"Ord. 4. HETERODONTA. Teeth of the hinge few, distinctly separated as cardinal and lateral, alternating, exactly filling the pits of the opposite valve; two equal muscular impressions. *Unionidæ, Cardiniidæ, Astartidæ, Crassatellidæ, Megalodontidæ, Chamidæ, Tridacnidæ, Erycinidæ, Lucinidæ, Cardiidæ, Cyrenidæ, Cyprinidæ, Veneridæ, Gnathodontidæ, Tellinidæ, Donacidæ.* The *Trigoniidæ* will form a distinct suborder.

"Ord. 5. ANISOMYARIA, or *Dysodonta.* Teeth of the hinge none or irregular; two very inequal or only one muscular impression; pallial line entire.

(*a*) Heteromyaria: *Aviculidæ, Mytilidæ, Prasinidæ, Pinnidæ.*

(*b*) Monomyaria: *Pectinidæ, Spondylidæ, Anomiidæ, Ostreidæ.*"

(*Zoological Record,* 1883, pp. 86 and 87, *Moll.*)

Dr. von Martens, certainly a most competent judge, has expressed the opinion that this classification "has several advantages in comparison with hitherto accepted classifications: (1) the distinction of a limited number of natural types, instead of an artificial separation into Monomyaria and Dimyaria, or Asiphonida and Siphonida; (2) the union of the Heteromyaria and the Monomyaria into one common chief division;" and (3) "the constitution of a special chief division for the Arcidæ and Nuculidæ, as these families offer very peculiar characters as well in the shells as in the gills and foot."

The present recorder is unable to appreciate any superiority of the new arrangement over that based on the muscles, and there are certainly more exceptions of the contents of the so-called "orders" to their diagnoses than in the case of the groups defined by the muscles. As Dr. Paul Fischer has already remarked (Journ. Conch., v. 24, p. 121), a single family (the Unionidæ) has representatives not only deviating from the diagnosis of the including "order" (Heterodonta), but exhibiting characters assigned to two others, *Anodonta* recalling the Palæoconchæ or Cryptodonta, and *Pleiodon* the Taxodonta. Undoubtedly Dr. Neumayr knew of these exceptions and regarded the forms and questions as derivatives from the normal Heterodonta. But the differences from the type and assumption of characteristics of others nevertheless exist. For this, if for no other reason, the value of such characters for orders is nullified. There is also a want of co-ordination between the hinge structure and modifications of other parts which

casts suspicion on the value of the former. There are likewise many other failures than those mentioned of constituents of groups to embody the requisites of the diagnoses of such groups. On the whole, then, we cannot concede that the new arrangement is superior to those that have preceded. It is, nevertheless, of some value as an incentive to further study of the subject, in order to test the value of various propositions.

The Eyes of Bivalve Mollusks.—If the edges of the mantle of even our common bivalve mollusks, such as the oyster, the hard clam, and the soft clam, are very closely examined, specks may be found which prove to be rudimentary eyes. These organs have been recently examined by Dr. Benjamin Sharp, of Philadelphia, who has studied them in the oyster, the hard clam, the soft clam, the common mussel (*Mytilus edulis*), the big clam (*Mactra solidissima*), and two razor-fishes (*Solen ensis* and *Solen vagina*). The pigmented cells found in these parts are essentially the same in all. The smallest of the cells were found in the oyster, and the largest in the hard clam. Experiments on these forms show their sensitiveness to light and shadow, and the cells showing the retinal character described leaves little doubt as to the power of vision. No nerves could be demonstrated passing direct to these cells, and probably those distributed to the general epidermis serve in transmitting the impressions. The visual power is so low that nerves have not yet been specialized for this purpose." (*Proc. Acad. Nat. Sc. Phila.*, 1884, p. 10).

The Greening of Oysters and its Cause.—There is always a reason or the appearance of a reason for a given phenomenon engendered by popular opinion, and one was devised to explain the cause of the green color so prevalent in the British oysters especially. The reasoning in this case was very facile.

Oysters are green; copper in oxidization becomes green. Therefore the green color of oysters is due to the absorption of copper; conseqently the bottom of the sea, or the sea itself, is pregnant with copper. The oysters have a "coppery taste," and thus give proof of the existence of copper.

Science doubted and suggested explanations, but not until lately has the question been approached in a severe critical and experimental manner. An old suggestion was then proved to be practically correct. The most recent and skilled of the inquirers into the cause and origin of the greening of the oysters are Mr. Puységur, an assistant commissioner of the navy department of France, and Mr. John A. Ryder, of the United States Commission of Fish and Fisheries.

Mr. Puységur has recalled the history of conjecture and research on the cause of the green color of oysters and given the results of his own investigations.

He tested the popular view that the color was the result of suffusion with copper. Even a meritorious chemist, Mr. Gaillard, had found cop-

per in oysters. But Mr. Gaillard, from scientific considerations, himself concluded that this was because some process was fraudulently employed to color the oysters, and that it consisted merely in immersing them in a solution of a salt of copper, and leaving them in it till they were saturated by it.

Mr. Puységur sought by experiment to ascertain whether copper was absorbable by the mollusk, and found that—

1. "An oyster which is placed in a bath of sulphate of copper is not colored at all."

2. "Death quickly follows when they are plunged into such a mixture."

He did not deny that chemists may have found copper in oysters, but his own direct experiments did not verify the absorption of the metal by the animals.

Copper, then, being out of the question, he sought to learn what was the cause.

Various observations and experiments were instituted, for a detail of which reference must be made to the original memoir of the author. His conclusions are thus summarized:

"There remains no longer any doubt as to the fact that the viridity of oysters is entirely due to the absorption or digestion of the soft parts of the *Naviculæ* held in suspension by the surrounding water; this definite experience also completely overturns the hypotheses which attribute it to the influence of the soil, to the mixture of fresh and salt water, to northeast winds; in a word, all the other conjectural causes to which this simple phenomenon has been childishly attributed are shown to be inadequate.

"It is evident, moreover, that the coloring matter is directly absorbed by the mollusks, and that the process takes place inside of the animals. If, in fact, dissolution of the coloring matter took place in sea-water, the water would be tinged as soon as the diatoms were blanched. Now, this is not the case. In fresh water, on the contrary, the coloring matter is immediately dissolved, and as a result the diatoms are blanched. A single drop of water placed on a slide containing the diatoms causes them to lose their color instantly. Finally, if a piece of filtering paper is saturated in the fresh water which has been placed on the diatoms, and it is afterwards dried, it will present absolutely the same color as the green oysters.

"These laboratory observations are, moreover, perfectly in accord with the phenomena observed by the oyster-culturists. Heavy rains cause the greenness of the claires to disappear, and the dry and salt-laden northeast winds, which augment the saturation of the waters, are, on the contrary, favorable to the production of the green coating in the claires."

Mr. Ryder supplemented Mr. Puységur's researches by observations of his own. His investigations convinced him of the correctness of Mr.

Puységur's conclusions. He had ascertained that the common American oyster (*Ostrea virginica*) "is affected by an acquired viridity at certain times and in certain places in precisely the same way as the common *O. edulis* of Europe and the *O. angulata* of the Tagus," as he had been able to learn from fresh material from Liverpool, obtained through the efforts of Professor Baird. "The cause of this peculiar staining of the soft parts of these animals is, therefore, very probably the same throughout both the European and the American oyster-growing regions."

Mr. Ryder further extended his studies to the florula of the water about the oyster beds and to the contents of the oyster's stomach. He found the special oyster diatom (*Navicula ostrearum*) abundant, and also other diatoms, and has thus summarized his results:

"Taking a survey of the lower groups of the vegetable world, which contain bluish-green pigments, and which are at the same time free-swimming in their habits, so as to place them within reach of the stationary oyster as food, there is none which actually seems more likely to be the source of the green tinge here discussed than the *Diatomaceæ*. And as there is no other class of forms so commonly and constantly met with in the alimentary canals of marine mollusks generally, I think we might take it for granted, for this reason alone, that they are the source of the coloration. In fact, it is rarely that I have met with any other vegetable organisms in the stomachs of oysters except diatoms, after having examined hundreds, by the excellent method of first removing the recently-swallowed contents of the gastric cavity with a pipette thrust into the mouth and through the short gullet. The 'bill of fare' of the animal can then be very deliberately studied under the microscope after the contents of the pipette have been pressed out upon and prepared for observation under a compressorium."

Mr. Ryder also endeavored to ascertain the elementary nature of the green thus dissolved out of the diatomaceous food of the oyster. His investigations could not be completed, but were carried far enough to justify an opinion. This was that "the coloring material in green oysters, on account of its solubility in water, its instability and color, is probably allied to phycocyanin, since we know that it is not chlorophyll, because the latter is insoluble in water." The spectroscope, however, gave him "entirely negative evidence upon this point."

Mr. Ryder concludes with the assurance that the belief or fear that green oysters are injurious or hurtful is without foundation. (*Ann. Rep. Com. Fish., &c.*, 1882, pp. 793–804, 1884.)

The assumption of the Spat stage by the Oyster.—The "metamorphosis and the post-larval stages of the development of the oyster" have been studied and described by Mr. John A. Ryder. His memoir is a long one and gives details of his methods of investigation and his various observations. The results have been summarized by himself in the following terms:

"1. The mouth in the larval oyster is nearly ventral in position, while in the adult it opens more nearly in the direction of the hinge or towards the antero-dorsal region.

"2. The retractor muscles of the velum probably atrophy at the end of the larval period; if they are to be regarded as the musculature of the primitive mantle organ, they are replaced in the spat and adult by the radiating and marginal pallial muscles.

"3. The intestine of the larva is a simple tubular organ; in the spat it has an internal ridge developed on one side, which finally becomes a pronounced induplicature in the intestine of the adult.

"4. The anterior adductor muscle of the larva is replaced by a permanent posterior adductor in the spat and adult. (Huxley.)

"5. The heart and gills are wanting in the larva; they are developed as post-larval organs. The gills are at first represented by only two folds; the outer pair are developed later, and apparently from before, backwards, or dorso-ventrally.

"6. The connective tissue of the spat and adult, including the organs derived therefrom, seems to be almost entirely developed during post-larval life.

"7. The blastocœl is mostly obliterated by the development of the connective tissues.

"8. The liver is represented by a pair of diverticula which grow out laterally from the walls of the stomach of the larva; its subsequent development and subdivision into a vast number of follicles is accomplished during post-larval life.

"9. Some time after fixation the larval oyster seems to lose the straight hinge border of its valves, which then acquire umbones; the valves retain their symmetry up to the time when the spat shell begins to be formed, and it is probable that most of the larval characters of the animal have disappeared when the formation of the spat shell begins; in other words, the veliger stage is past and is at once replaced by a structual condition of the soft parts which approximates that observed in the adult." (*Ann. Rep. Com. Fish., for* 1883, pp. 779–791, 1884.)

A remarkable new Type of Mollusks.—All the acephalous mollusks hitherto known have distinct external valves on each side, although in some, such as in the ship-worms (Teredinids) and the watering-pot shells (Aspergillids), the valves are extremely reduced; but in a form recently obtained from California, external valves are not at all apparent. When living, the animal is apparently of the "shape of a small globose *Cypræa* [or cowrie] of inflated ovoid form, and being translucent, jelly-like, dotted above with small rounded papillæ, which appear of an opaque white on the general translucent ground." When fresh, according to the discoverer of the specimens, Mr. C. R. Orcutt, the animal was "over an inch in length," but the contraction in alcohol is such that the specimens, when received by Mr. C. H. Dall, were reduced to "less than half an inch in length."

"The mantle which covers the dome of the body is tough and thick; the sides are smooth and nearly free from papillæ. The superior median line is a little depressed. The basal part of the anterior end in life is prolonged beyond the general mass in a wide trough, with the convexity upward, and somewhat expanded at its anterior extremity. About one-third of the way from the anterior end, the mantle is perforated by an orifice, which pierces it in the vicinity of the mouth. The edges of this orifice project from the general surface, and it is lined with close-set small papillæ. At about the same distance from the posterior end is another tubular perforation, holding a similar relation to the anus; which has, however, plain edges, and is not internally papillose." When the mantle is open, the small valves become apparent. These are "inclosed in two little sacs in the substance of the mantle. The umbones are near together, apparently connected by a brown gristle, resembling an abortive ligament, and are nearly over the heart. The valves are about ten millimetres long, and one millimetre wide, destitute of epidermis, prismatic or pearly layers. There are no muscular or pallial impressions, no adductors, hinge, or teeth." They resemble in form the exterior of the shell called Gervillia, and have a pure white color. "As they lie in the body, they diverge at a rather wide angle from the beaks, forward. The embryonic valves are retained like two tiny bubbles on the umbones."

The affinities of this new form are even doubtful. The classification chiefly in vogue for the bivalve mollusks is based upon the number and relations of the adductor muscles of the shell, and Mr. Dall remarks that, if such classification is retained, the new form should be distinguished as the representative of a distinct order, which might be called "*Amyaria.*" He doubts the propriety of such a separation, however, but very properly claims that it is the type of a new family which he calls *Chlamydoconchæ*, and which would be generally named, with the ordinary family termination, *Chlamydoconchidæ.* The species is named after its discoverer, Mr. C. R. Orcutt. It is evident, observes Mr. Dall, that "the genus does nothing toward bridging the gap between the gastropods and pelecypods [or bivalve mollusks], but is simply a remarkably aberrant form of the latter group, and probably derived from some form with an external shell. It is able, according to Mr. Orcutt, by sphincter-like contractions of the mantle, to produce currents of water over the gills, which are probably finally ejected by the anal tube." (*Science*, IV, pp. 50, 51.)

Gastropods.

The Operculum of Gastropods.—The development of the operculum of the Gastropods has been studied by F. Houssay on examples of *Littorina*, *Murex*, and *Purpura.* The foot alone is implicated in the formation of the operculum, but "only a small, very clearly defined portion of it." Quite close to the margin of the operculum which adjoins the columella when the length is restricted, a small transverse fissure was found which

penetrated about a millimeter into the thickness of the columellar muscle and which occupies the whole length of the foot. "The walls of this pedal fissure are lined with a peculiar epithelium, folded, or rather goffered, so as to somewhat resemble the polypary of a Mæandrina." Then it has a very delicate and very flexible transparent lamella, which can be taken out with a fine needle, and which after remaining some time in the air dries and acquires a horny appearance. It is found that "the epithelial cells of the fissure excrete a structureless material of a yellowish color and strongly refractive, which, by agglomeration, constitutes the hyaline lamella. The latter issues from the pedal fissure and adds itself to the old operculum."

"The newly-formed parts apply themselves to the epithelium situated between the fissure and the parts of the operculum which are already fixed. At this point the epithelial cells are but feebly adherent to each other, and only by their basal part, a remarkable exception among epithelia. From this it results that the still plastic opercular material invests these cells, and even diffuses itself somewhat among the elements of the subjacent tissues (muscular fibers and connective cells). It is thus that by successive appositions of new parts issuing from the pedal fissure the striæ are formed, of which only the most salient are visible to the naked eye or the lens."

"On the other surface of the operculum we must distinguish two regions, the surface of insertion of the columellar muscle, and the free internal surface. It is very easy to see that the free internal surface and the outer surface of the operculum have not the same constitution. The inner surface is covered with a homogeneous layer which forms, as it were, a varnish without any striæ perceptible to the eye. This coating may even be so thick that we cannot see through it the striæ of the other surface. In other cases it is delicate enough not to hide them. This difference of constitution arises from a difference of origin. In front of the surface of insertion the metapodium forms an interior expansion or lip, which, during the life of the animal, is constantly applied against the inner unattached part of the operculum. The epithelial cells of this anterior lip produce the varnish.

"It still remains to ascertain why the opercular material is rolled into a spiral. To elucidate this point we must study the muscular impression. As the operculum grows, the surface of insertion of the operculum is displaced with a slight movement of rotation, since during the same time the shell grows in a spiral. The muscle attaches itself to the newly formed parts, abandoning the old parts on the side of the parietal margin. These stages of the columellar muscle are marked by striæ independent of those of the superior surface. We observe them when preparing an operculum after removing all traces of muscle. By studying these lines we can even understand why there are opercula of which the form always remains the same, while there are others of which the form varies with the age of the animal. The latter are said to have a *nucleus*

of formation. The posterior secreting portion of the foot always retains the same form in the first case, whereas in the second we see it from nearly circular become almost straight." (*Comptes Rendus Acad. Sci.*, 1884, Jan. 28, p. 236; *Ann. & Mag. Nat. Hist.* (5), XIII, pp. 304–306; *Arch. Zool. Expér. et Gén.* (2), IV, pp, 869, 870; *Rev. Sci.*, XXXIV, pp. 343, 344; *J. R. M. S.* (2), IV, pp. 869, 870.)

Cephalopods.

Development of the Gills in Cephalopods.—The development of the gills in Cephalopods has, until recently, been but little, if at all, known. The subject was investigated in 1884 by M. L. Joubin. It seems from his investigations that "the branchiæ of the embryo make their appearance at the beginning of the development in the form of two small buds, situated symmetrically with relation to the antero-posterior plane upon the middle of what will eventually become the posterior wall of the pallial cavity. The bud, produced by a pushing force of the epithelial layer by the cells of the subjacent layer, soon elongates and forms a small, well-differentiated eminence, rounded at the apex and attached by a broad base." No vibratile cilia, such as line the pallial cavity, were detected. "The bud afterwards flattens so as to present two surfaces: a posterior one, applied against the visceral mass, and an anterior one, which is subsequently covered by the mantle which bounds the respiratory cavity superiorly."

Upon this little lamina "a first horizontal fold appears towards the middle, then a second nearer to the point, then a third still nearer the free extremity, and so on. These folds form depressions upon one of the surfaces corresponding with elevations upon the other surface; the branchial bud has, therefore, become an undulated lamina; gradually other folds appear, always toward the point, while the whole organ at the same time increases in dimensions."

Of the vessels which form the branchia, "the one which conveys the blood to it appears early at the commencement of the formation of the laminæ; it occupies nearly the center of the organ, and is comprised within the base of the laminæ and the gland of the branchia, which is also distinctly marked at this period. The efferent vessel is formed upon the crest of the branchia and on the outer border of the laminæ; it is undulated like the parts which bear it, and issues from the branchia at the base, to be continued by the auricle of the heart." (*Comptes Rendus Acad. Sci.*, 1883, Nov. 12, p. 1076; *Ann. & Mag. Nat. Hist.* (5), XIII, pp. 67–69.)

PROTOCHORDATES.

Tunicates.

Development of Salpa.—Much has been written about the development and morphology of *Salpa*, but some obscurity still hangs over the subject. The group has been investigated recently by Prof. W. Salensky,

who has examined four species—*S. punctata*, *S. fusiformis*, *S. bicaudata*, and *S. democratica*. The sum of his researches has been thus recorded in the Journal of the Royal Microscopical Society: "The developmental process of *Salpa* is so peculiar that it is very difficult to compare it with other known types of development; the fact that the follicular cells take a share in the production of the embryo (the process of development being therefore both sexual and asexual) is not, however, confined to this group. Lankester has described a very similar state of things in Cephalopoda, where the inner capsular membrane, the follicle itself, grows into the ovum and partly forms the nutritive yolk; recent researches also into the Vertebrata tend to show that the yolk is partly from the cells of the follicle. *Salpa bicaudata* appears to represent the most simple development of all the species, while further complications, such as the formation of a part of the embryo by cells of the oviduct, tend to remove other *Salpæ* further from the normal mode of development exhibited in the animal kingdom." (*Mittheil. Zool. Stat. Neapel*, IV, pp. 327–402, 6 pl.; *J. R. M. S.* (2), IV, pp. 368, 369.)

VERTEBRATES.

Fish-like vertebrates.

British Fishes.—The work of Dr. Francis Day, on "The Fishes of Great Britain and Ireland," has been lately completed, and in it we have an excellent *résumé* of what is known of the finny inhabitants of the home empire. The system and nomenclature as well as definitions of Dr. Günther are essentially adapted for the generic and supergeneric groups, and a full synonymy and description are given of each species; then follows information respecting the "names," "habits," "means of capture," "baits," "breeding," "life history," "diseases," "uses," "as food," and "habitat" of the species if known or so far as known to the author.

It may be of interest to compare the constitution of the British fauna with that of a limited region of Eastern America, and in the following tables the comparative data are given. The data in the work of Day for the British fishes, and Goode and Bean for the American, as given in "A List of the Fishes of Essex County, including those of Massachusetts Bay," are accepted for the species. To bring the information to a common denominator, the most recent systematic results of the American ichthyologists (who are all in essential accord in this respect) are applied to the superspecific groups. The data are given (under family names adopted by American authors) as to (*a*) the number of species recorded from (1) Great Britain and (2) Massachusetts Bay, &c., (*b*) the number of genera represented in (3) Great Britain and (4) Massachusetts, and (*c*) the (5) species and (6) genera shared in common by Great Britain and Massachusetts. The Massachusetts region is limited purposely in the tables to the waters north of Cape Cod, as the exhibit thus brings out best what are the features common to the two. The

families represented south of the cape are, however, added and distinguished by italics (but without detailed information) to indicate the peculiarities of the western side of the Atlantic. The Bassalian forms are omitted unless they have actually been caught near the shore. Inasmuch as very deep water occurs much nearer the British coast than the New England, considerably more deep-sea fishes have been found on the British coasts than along the American.

In the following tables those families whose names are bracketed in one set in the margin are included in a single family by Dr. Day, under the name indicated by the letter (D); the families here adopted are as a rule more restricted than Dr. Day's. In one case, however, as will appear by one of the notes, the constituents of one family are scattered among three by Dr. Day, who has followed Dr. Günther.

Class, order, suborder, and family.	Species.		Genera.		Common.	
	G. B.	M.	G. B.	M.	Sp.	Gen.
CLASS OF LEPTOCARDIANS.						
Order Amphioxi.						
Branchiostomidæ (Cirrostomi D.)	1	0	1	0	0	0
CLASS OF MYZONTS.						
Order Hyperotreta.						
Myxinidæ (D.)	1	1	1	1	1	1
Order Hyperoartii.						
Petromyzontidæ (D.)	3	1	2	1	2	1
CLASS OF SELACHIANS.						
Order Holocephali.						
Chimæridæ (D.)	1	0	1	0	0	0
Order Opistharthri.						
Hexanchidæ (Notidanidæ D.)	1	0	1	0	0	0
Order Anarthri.						
(Suborder Squali.)						
{ Oxynotidæ	1	0	1	0	0	0
{ Spinacidæ (D.)	1	1	1	1	1	1
{ Scymnidæ	1	1	1	1	1	1
{ Echinorhinidæ	1	1	1	1	1	1
Scylliorhinidæ (Scylliidæ D.)	3	0	3	0	0	0
{ Galeorhinidæ (Carchariidæ D.)	3	2	3	2	0	1
{ Sphyrnidæ	1	1	1	1	1	1
{ Alopiidæ	1	1	1	1	1	1
{ Odontaspididæ	0	1	0	1	0	0
{ Lamnidæ (D.)	1	2	1	2	1	1
{ Cetorhinidæ	1	1	1	1	1	1
(Suborder Rhinæ.)						
Squatinidæ (Rhinidæ D.)	1	0	1	0	0	0
Order Platysomi.						
(Suborder Pachyura.)						
Raiidæ (D.)	10	5	1	1	1	1
(Suborder Electromi.)						
Torpedinidæ (D.)	2	1	1	1	0	1
(Suborder Masticura.)						
Trygonidæ (D.)	1	0	1	0	0	0
{ Cephalopteridæ	1	0	1	0	0	0
{ Myliobatidæ (D)	1	0	1	0	0	0

Class, order, suborder, and family.	Species. G. B.	Species. M.	Genera. G. B.	Genera. M.	Common. Sp.	Common. Gen.
CLASS OF TELEOSTOMES OR FISHES.						
Order Chondrostei.						
Acipenseridæ (D.)	1	2	1	1	1	1
Order Malacopterygii.						
Albulidæ						
Elopidæ						
Dussumieridæ						
Clupeidæ (D.)	5	6	3	4	1	3
Dorosomidæ						
Engraulididæ	1	1	1	1	0	1
Argentinidæ	2	1	2	1	0	1
Thymallidæ	1	0	1	0	0	0
Salmonidæ (D.)	7	2	3	2	1	2
Order Iniomi.						
Sternoptychidæ (D.)	1	0	1	0	0	0
Maurolocidæ ([1])	1	1	1	1	1	1
Paralepididæ (Scopelidæ D.)	1	0	1	0	0	0
Order Plectospondyli.						
Cyprinidæ (D.)	14	5	10	5	1	1
Cobitidæ	2	0	2	0	0	0
Catastomidæ	0	2	0	2	0	0
Order Nematognathi.						
Siluridæ	0	1	0	1	0	0
Order Apodes.						
(Suborder Enchelycephali.)						
Congridæ	1	1	1	1	1	1
Anguillidæ	1	2	1	1	0	1
(Suborder Colocephali.)						
Murænidæ (D.)	1	0	1	0	0	0
Order Opisthomi.						
Notacanthidæ (D.)	1	0	1	0	0	0
Order Teleocephali.						
(Suborder Haplomi.)						
Esocidæ (D.)	1	2	1	1	0	1
Umbridæ						
Cyprinodontidæ	0	4	0	2	0	0
(Suborder Syrentognathi.)						
Exocœtidæ (Scombresocidæ D.)	3	1	3	1	1	1
Belonidæ	1	1	1	1	0	0
(Suborder Percesoces.)						
Sphyrænidæ (D.)	1	0	1	0	0	0
Atherinidæ (D.)	2	1	1	1	0	0
Mugilidæ (D.)	2	1	1	1	0	1
(Suborder Rhegnopteri.)						
Polynemidæ						
(Suborder Acanthopterygii.)						
Holocentridæ						
Pomatomidæ	0	1	0	1	0	0
Carangidæ (D)[2]	8	4	3	8	0	0
Bramidæ	1	0	1	0	0	0
Coryphænidæ (D)[3]						
Stromateidæ (D)[4]	4	2	3	2	1	1
Scombridæ (D)	7	6	5	5	5	4
Lepidipodidæ	1	0	1	0	0	0
Trichiuridæ (D)	1	1	1	1	1	1

[1] The genus Maurolicus was included by Day in the family Sternoptychidæ.
[2] In the family Carangidæ was also included by Day the genus *Capros*, type of the family Caproidæ related to the Zenidæ.
[3] In the family Coryphænidæ were also included by Day the genera *Lampris* and *Luvarus*, types of very different families.
[4] Other species of the family Stromateidæ are referred by Dr. Day to two other families, the *Leirus perciformis* (*Pammicas perciformis* Day) being included with Carangidæ and the *Schedophilus medusophagus* being placed in the family Coryphænidæ.

Class, order, suborder, and family.	Species.		Genera.		Common.	
	G. B.	M.	G. B.	M.	Sp.	Gen.
CLASS OF TELEOSTOMES OR FISHES—Continued.						
Order Teleocephali—Continued.						
(Suborder Acanthopterygii)—Continued.						
Histiophoridæ	0	2	0	2	0	0
Xiphiidæ (D)	1	1	1	1	1	1
Zenidæ (Cyttidæ D)	1	1	1	1	0	0
Caproidæ (Carangidæ gen. Day)	1	0	1	0	0	0
L.. aridæ (Coryphænidæ gen. Day)	1	0	1	0	0	0
Lampridide (Coryphænidæ gen. Day)	1	1	1	1	1	1
Elacatidæ						
Ephippiidæ						
Chætodontidæ						
Teuthididæ						
Trachinidæ (D.)	2	0	2	0	0	0
Uranoscopidæ						
Batrachidæ	0	1	0	1	0	0
Sciænidæ (D.)	1	3	1	3	0	0
Sparidæ (D)	10	1	5	1	0	0
Pristipomidæ						
Lutjanidæ						
Gerreidæ						
Pimelepteridæ						
Lobotidæ						
Centrarchidæ	0	5	0	4	0	0
Serranidæ	3	1	3	1	0	0
Labracidæ	1	2	1	2	0	0
Percidæ (D.)	2	3	2	3	0	1
Priacanthidæ	0	1	0	1	0	0
Mullidæ (D.)	1	0	1	0	0	0
Pomacentridæ						
Labridæ (D.)	7	2	6	2	0	1
Scorpænidæ (D.)	1	1	1	1	1	1
Hemitripteridæ	0	1	0	1	0	0
Cottidæ (D.)	4	6	3	4	1	2
Agonidæ (D)[5]	1	1	1	1	0	0
Triglidæ[6]	7	2	2	1	0	0
Dactylopteridæ	0	1	0	1	0	0
Liparididæ	2	2	1	1	2	1
Cyclopteridæ (Discoboli D)	1	2	1	2	1	1
Gobiidæ (D.)	9	0	3	0	0	0
Callionymidæ (D.)	2	0	1	0	0	0
Cepolidæ	1	0	1	0	0	0
Blennidæ (D.)	4	0	2	0	0	0
Anarrhichadidæ	1	2	1	1	1	1
Stichæidæ	1	3	1	3	0	0
Xiphidiontidæ	1	1	1	1	1	1
Cryptacanthodidæ	0	1	0	1	0	0
Zoarceidæ[7]	1	2	1	2	0	1
Ophidiidæ (D.)	1	0	1	0	0	0
Fierasferidæ	1	0	1	0	0	0
Ammodytidæ	3	2	2	1	0	1
(Suborder Tæniosomi.)						
Trachypteridæ (D.)	1	0	1	0	0	0
Regalecidæ	1	0	1	0	0	0
(Suborder Xenopterygii.)						
Gobiesocidæ						
(Suborder Discocephali.)						
Echeneididæ (Scombridæ g. D.)	1	3	1	3	1	1
(Suborder Anacanthini.)						
Ranicepitidæ	1	0	1	0	0	0
Gadidæ (D.)	16	10	11	7	5	6
Merluciidæ	1	1	1	1	0	1
Macruridæ (D.)	1	1	1	1	0	1

[5] The Agonidæ, as well as the Dactylopteridæ and some Triglidæ (Peristedion), were included by Day in a group called the family Cataphracti.
[6] The Cottidæ includes the Triglæ; the genus *Peristedion* is referred by Day to the Cataphracti.
[7] The Zoarceidæ were divided by Day, the typical species being included in the family Blenniidæ, and the Lycodinæ and Gymnelinæ constituted the family Lycodidæ.

Class, order, suborder, and family.	Species.		Genera.		Common.	
	G. B.	M.	G. B.	M.	Sp.	Gen.
CLASS OF TELEOSTOMES OR FISHES—Continued.						
Order Teleocephali—Continued.						
(Suborder Heterosomata.)						
Pleuronectidæ (D.)	14	9	11	8	3	6
Soleidæ	4	1	3	1	0	0
Order Hemibranchii.						
Gasterosteidæ (D.)	3	4	3	3	2	2
Fistulariidæ	0	1	0	1	0	0
Centriscidæ (D.)	1	1	1	1	1	1
Order Lophobranchii.						
Syngnathidæ (D.)	5	2	4	1	0	1
Hippocampidæ	1	1	1	1	0	1
Order Plectognathi.						
(Suborder Sclerodermi.)						
Balistidæ[1]	2	3	1	3	1	1
(Suborder Ostracodermi.)						
Ostraciontidæ	0	1	0	1	0	0
(Suborder Gymnodontes.)						
Tetrodontidæ[2]	1	1	1	1	0	0
Diodontidæ[2]						
Molidæ[2]	2	1	2	1	1	1
Order Pediculati.						
Antennariidæ						
Ceratiidæ						
Lophiidæ[3]	1	1	1	1	1	1
Maltheidæ						

[1] Sclerodermi D. [2] Gymnodontes D. [3] Pediculati D.

Some interesting and curious deductions flow from a comparison of the data embodied in these tables.

The fresh-water fishes are mostly very different in the two regions. The British isles are not distinct from the neighboring continent, so far as its fishes are concerned, and almost all are conspecific with continental forms, the only difference being that there are fewer species and an absence of some characteristic European types. Massachusetts and its neighbors exhibit a similar relation to the rest of the American continent, in the paucity of species as well as deficiency of peculiar American types, and this feature is so well marked that more than a quarter of a century ago Professor Agassiz denominated the region the "Zoological island of New England." Both regions, however, so far as the faunas go, are true to their continents. Notwithstanding the so much talked of small size of the British area, the fishes of the same diversiform families are on the whole larger than those of America, or, in more exact terms, there is a lack of the very small species. The special British Cyprinids and Percids, for example, are larger than those of New England, and none are as small as the peculiar American types, such as the little minnows, shiners, and darters. (It may be remarked that for size, the suckers take the place of the large European Cypri-

nids.) The generic types common to the two regions are, however, about equally developed, such as the lampreys, eels, salmonids, pike, yellow perches, millers-thumbs, burbot, and sticklebacks. On one hand the family of Loaches is the only one wanting in America, although there is no grayling in New England; on the other, the suckers, catfishes, mummichogs or Cyprinodontids, and sunfishes of New England are wanting in Britain. The common American charr or brook-trout is larger than the British species and takes the place in New England of the true trout of England, a type deficient from the Eastern American fauna. The peculiar American species of the pike family are smaller * than the common pike common to the two countries, and which alone is a native of Britain, and indeed of Europe generally.

There is another feature of interest. It is that, with the exception of the sticklebacks, none of the British fresh-water fishes take special care of their eggs or young, while, of the American types, the catfishes and sunfishes are noted for their care of both the eggs and young.

If now we compare the salt-water species, we find that Britain has a lancelet, a six-gilled shark, an Oxynotid, three Scylliorhinids, many more rays, a Murray (Murænid), a scabbard-fish (Lepidopodid), a John Dory (Zenid), a boar-fish (Caproid), very many more Sparids, seven Labrids to New England's two; many more Triglids, and all of a special genus; two Callionymids, nine gobies, four true blennies, and more Gadids, flatfishes, and soles, a Centriscid, and more pipefishes, types wanting or more poorly represented in New England.

To somewhat balance all these absentees, New England has an Odontaspidid, several Cyprinodontids, more Sciænids, more Labracids, a Hemitripterid, a Dactylopterid, three Stichæids, a Cryptacanthodid, a Fistulariid, an Antennariid, and a Maltheid—types entirely unknown or less represented in England.

In this comparison no account has been taken of deep-sea types (which, on account of the proximity of deep water, are more numerous near the British shores) or those that are mere wanderers to either shore. On the other hand, types that are represented in the waters of Massachusetts, though they may not have been credited to Massachusetts Bay, have been kept in view.

The oldest known fish.

Until lately the oldest known fishes had been obtained from the English Ludlow beds, which are near the top of the Upper Silurian, and none had been found in America lower than the Devonian. In the past year, however, remains were found which indicate the existence of what have been supposed to be fishes in still lower beds of the Silurian, in Pennsylvania. They were discovered by Prof. E. W. Claypole

* One of the American pikes (*Esox nobilior*), but not occurring in Massachusetts, is larger than the European, and the largest and finest of the family.

while engaged "on work on the palæontology of Pennsylvania." First, he found in what he calls the "Bloomfield sandstone," which "lies at the top of the variegated shale or marl, the middle portion of the great mass of the Onondaga," certain remains analogous to those occurring in the Ludlow beds. The Ludlow beds are believed to have their equivalents in America in the Lower Helderberg, and inasmuch as the Onondaga is below the Helderberg, the time in which the animals lived that have left their remains in the Bloomfield sandstone must be still further back. The remains in question indicated a species of the genus *Onchus* and two of a genus related to *Scaphaspis* of the Pterichthyidæ, but different to such an extent as to have impelled Professor Claypole to refer them to a new genus called *Palæaspis*.

Next, "a thousand feet lower down, in the middle of the red shale," Professor Claypole found in a thin bed comminuted fish scales or shields resembling in many points those of *Palæaspis*.

Further, "five hundred feet lower still, below beds indisputably of Clinton age," in the "well-known iron sandstone," is "a thin layer thickly charged with comminuted scales in much better condition than those in the red shale. With these occurs a spine somewhat like those from the Bloomfield sandstone," which Professor Claypole considered to indicate a new *Onchus*—the *O. clintoni*.

Professor Claypole asserts that "it is evident that in these fossils we have the most ancient relics of vertebrate life yet known from any part of the world."

The Professor concludes that, "in thus carrying down the remains of fish almost to the base of the Upper Silurian rocks, it becomes evident that we must seek in some part of our Cambro-Silurian series to find yet earlier forms. It is not likely that these are the first that existed. Lower beds must be searched." (*Am. Nat.*, v. 18, pp. 1222–1226.)

Leptocardians.

Number of Branchiostomids.—The lowest type, by all odds, of true Vertebrates is the genus *Branchiostoma*, a representative at the same time of a peculiar family, order, and class. The first example obtained was described over a century ago by the celebrated Pallas as a *Limax*, or slug. Since then, several species have been proposed on differences in the number of transverse impressions representing the limits of what are now called myocommas. These, however, were all ignored by Dr. Günther, in 1870, and the species were all "lumped" together under *Branchiostoma lanceolatum*. "The recent discovery of a second undoubtedly distinct species of Leptocardian on the coast of Australia [*Epigonichthys cultellus*], as well as the acquisition of several well-preserved examples," induced Dr. Günther "to re-examine all the specimens in the British Museum," and he "convinced" himself that the view formerly held by him "is incorrect, and that Sundevall was quite right in drawing atten-

tion to the number of myocommas as an excellent taxonomic character." Dr. Günther was thus led to recognize six species of *Branchiostoma:* (1) *B. elongatum*, Peru; (2) *B. bassanum*, Bass Straits; (3) *B. Belcheri*, Borneo; (4) *B. caribœum*, West Indies; (5) *B. lanceolatum*, Europe; (6) *B.* [*Epigonichthys*] *cultellus*. The *B. bassanum* was new. (*Rep. Zool. Coll. Alert*, pp. 31–33.)

Sclachians.

An Eel-like Shark.—Perhaps the most interesting discovery of the past year among new vertebrate forms is a species of shark made known by Mr. Samuel Garman, of Cambridge, under the name of *Chlamydoselachus anguineus*. All the previously known sharks are pretty uniform in having the body of a more or less fusiform contour and comparatively stout; any differences in contraction or elongation are comparatively slight. The new form, however, differs widely from all other described species, and is so elongated as to suggest the snake- or eel-like form, which has struck Mr. Garman and induced him to give to it the name *anguineus* or snake-like. In other respects, it has more characteristics in common with the Notidanids or Hexanchids (that is, the family represented by the gray shark of Europe) than with any other. As in the Notidanids, there is only one dorsal fin, and in the new shark this is reduced in size and far behind, opposite the anal; the latter is much larger than the dorsal and is elongated; the ventral fins are also behind the middle of the length and reach to the anal. "The head is broad, slightly convex on the crown, and has a look about it," says Mr. Garman, "that reminds one of some of the venomous snakes." The mouth opens at the anterior extremity, and is not overhung by the snout, as in most sharks. The gape is very wide, lateral, and extends far behind the eyes. The nostrils are also unlike those of ordinary sharks in being lateral. As in the Notidanids, the branchial apertures are in increased number (six), but those in front are very wide, and are quite characteristic in that "the frill or flap covering the first opening is free across the isthmus, as in [some] fishes, and hangs down about an inch." The teeth are also very peculiar. As in other sharks, they are arranged in rows across the jaws. In detail, "they are all alike; each tooth has three slender, curved, inward-directed cusps, and a broad base, which extends back in a pair of points under the next tooth, thereby securing firmness and preventing reversion. In the twenty-eight rows of the upper jaws and twenty-seven of the lower there are three times as many rows of the fangs or cusps."

Mr. Garman, in considering the relations of this remarkable animal, thought that most resemblance was to be found in the dentition to the teeth of *Cladodus*, of the Devonian, "but the cusps were erect instead of reclining, and the enamel was grooved or plicate instead of smooth." He was impressed by a study of the animal "with the idea that, away back in times when selachia and fishes were more alike, he would

have a better chance to trace the affinities." Mr. Garman was finally inclined to consider the species as the type, not only of a new genus and family but even of "a new order, to which the name Selachophichthyoidi might be given, and which stands nearer the true fishes than do the sharks proper."

The new shark was 5 feet long and less than 4 inches in greatest diameter. It was obtained in Japan.

Next, Professor Cope, soon afterwards, in a communication to Science, expressed the opinion that the newly described shark was congeneric with the *Diplodus* or *Didymodus* of the Devonian epoch, and that therefore it was the oldest living type of Vertebrata.

In a subsequent number of Science, Professor Gill commented upon the views already expressed and had to differ from both gentlemen. He was disposed to agree with Mr. Garman in the conclusion that *Chlamydoselachus anguineus* approached nearer the true fishes than do the sharks proper, not because it appeared to be in the line of descent between the two, but because it was nearer the primitive line from which both types have diverged. It is doubtful, however, whether it is a more primitive type than the Notidanids. As to its relations to extinct types, however, he dissented from both Mr. Garman and Professor Cope, and doubted whether it was closely related to any known extinct forms, urging that both of the forms to which it had been approximated by Messrs. Garman and Cope were very widely separate. The *Cladodus* and its relatives were at least subordinally distinct, and *Diplodus* or *Didymodus* (which, he showed, should be called *Pleuracanthus*) appeared to have had no relations whatever to it, and apparently did not belong to the same order or even subclass. On the whole *Chlamydoselachus* appeared to him to be quite clearly related to the Notidanids, but in a revised natural system of the Squali, the two families might be considered as representatives (and the only known representatives) of distinct suborders—the Notidanids of the suborder Opistharthri, and the Chlamydoselachids of the suborder Pternodonta or Selachophichthyoidei. The two seem to be closely related, however. (*Science*, v. 3, pp. 116–117 (*Garman*); v. 3, p. 275 (*Cope*); v. 3, pp. 345–346 (*Garman, Gill*); v. 4, p. 484; (*Garman*) v. 4, p. — (*Gill*); *Bull. Essex Inst.*, v. 16.)

Teleostomes or fishes.

The lateral line of Fishes.—The so-called lateral line of fishes and its extension on the head has been a subject of many investigations. One of the latest published on the subject is by M. Paul De Séde, who has paid special attention to the histology and development thereof. We cannot enter upon the anatomical details and must remain content to briefly consider the results of some of the experiments made by the author. He had undertaken the vivisection of certain fishes, subjecting them to anæsthesia and then experimented upon them in several ways. He chiefly employed chloroform, and placed the fish in a glass jar three-

fourths filled with water and closed by a glass cover. In the center of the jar, a small bottle filled with chloroform had been previously attached so that it should not be thrown out of place. The neck of this bottle extended about a centimeter above the level of the water and allowed the vapor of the chloroform to circulate freely. The effect of the chloroform on the fish was manifested at first by violent attempts to escape; then the animal swam on one side, made some turns round the jar, and, at the end of several minutes, fell to the bottom of the jar completely anæstheticized. If in this condition it is allowed to remain three to four minutes, the cover being taken off, it dies and floats belly upwards to the surface; consequently, it should be taken out as soon as it falls to the bottom of the jar and is motionless.

Water charged with carbonic acid may be substituted for the chloroform. It has been suggested, as a result of the experiment of Brown-Séquard, that carbonic acid brought directly in contact with mucous surfaces possesses powerful anæsthetic properties. Thus anæstheticized, the subjects can easily stand a resection of the lateral nerve for a length of one or two centimeters according to size. The lateral nerve was cut out and the animal did not manifest pain in any manner. But the operation must be performed with delicacy and quickness, and this result was not obtained without numerous attempts. The fishes operated upon, while living, were placed in a large bottle where they were allowed to rest. They exhibited at first the characteristic sluggishness which follows the absorption of chloroform, and it was manifested in various incoherent movements. When they had entirely recovered from the effects of their being subjected to the chloroform, their movements were watched with interest. The fishes operated upon, it was observed, swam with great slowness and hesitancy in the jar, evidently feeling their way; while those in which the lateral line was perfect passed through the water and between obstacles with little or no diminution of speed. It seemed evident to M. De Séde, as a result of his experiments, that the lateral line has a tactual or sensitive function and supplements or supplies the place of vision. The lateral line takes cognizance of the currents and other movements of the water and the fish knows its own swiftness and how to regulate it. Moving in an element agitated without cessation, it perceives the least displacement; living in the midst of enemies which surround it on all sides it becomes conscious of their approach by the slightest movements of the water. The lateral line is, then, the result of an adaptation to aquatic life, an adaptation which ceases with this mode of existence and disappears, as we know is the case in the amphibians, when the animals become adult and leave the water. The organs of general sensibility, these tactual corpuscles, are grouped in a more delicate apparatus, affecting special dispositions absolutely different from those which characterize the other organs of the definite senses. It may be said, therefore, that in the lateral line a sixth sense in the full meaning of the word is de-

veloped. In other words, the lateral line is a tactual organ specialized to the same extent as those organs in certain deep-sea fishes which give light. The anatomical characteristics of the lateral line are very diversified, but in all cases there is a similar adaptation for the perception of sensations, and the apparatus is more or less protected by the integuments; it is for the purpose of communicating with the sensorium through the intervention of the lateral nerve. (*Revue Scientifique*, t. XXXIV, pp. 467–470.)

Hermaphroditism of Fishes.—It has long been known that hermaphroditism occurs in a number of fishes, and in some of them it is so general as to almost constitute the normal form. The subject has lately been reinvestigated by Max Weber. He has re-examined especially the well-known cases of hermaphroditism of the sea perches of the Mediterranean, of the genus *Serranus*, and also of certain Sparids. The greatest number of species in which hermaphroditism is manifested are Physoclists or Acanthopterygians; only three phystomous fishes (the carp, the herring, and the pike) have yielded hermaphrodites. Besides the three species of *Serranus* and one of *Sparus*, hermaphroditism has been detected more or less frequently in various species related to *Sparus*. The family of Sparids, indeed, furnishes no less than six species subject to hermaphroditism. These are (1) *Sparus aurata*, (2) *Pagellus mormyrus*, (3) *Sargus annularis*, (4) *Sargus Salviani*, (5) *Charax puntazzo*, and (6) *Box salpa*.

In the family of Scombrids, hermaphroditism has been observed in the common mackerel (*Scomber scombrus*); in the Percids, in the river perch; and in the Labrids in *Labrus mixtus*. One species of Ophidiids, no less than three species of the family of Gadids, and one of the Soleids have also yielded hermaphroditic individuals: of the Ophidiids, the *Ophidium barbatum*; of the Gadids, the common cod, the whiting, and the fresh-water burbot or cusk; and of the Soleids the common sole. It is especially the characteristics of hermaphroditism in the perch and codfish that Mr. Weber has studied, and he has sought to learn the causation of the phenomenon. The result, he contends, arises from the primordial sexual indifference of the materials out of which are, in time, developed the genital glands. At the moment of sexual specialization, a portion of the elements of which these embryonic materials are constituted develop toward the male sex, while the other portion undergoes successive modifications which tend to the female sex, and from these diverging tendencies arises without doubt the appearance of true hermaphroditism. It is recalled that hermaphroditism is most common in fishes and becomes rarer in the higher vertebrates in which sexual differentiation has become more decided.

The species studied by Dr. Weber are all common European fishes. Hermaphrodites have likewise been found in extra-European fishes, especially among the Serraninæ and the Lutjaninæ. (*Nederland. Tijdschr. Dierkunde*, I, p. 84; *Revue Scientifique*, t. XXXIV, pp. 376, 377.)

Serrated Throat Appendages of Amia.—The so-called "mud-fish" or "lawyer" (*Amia calva*) of our Western and Southern lakes and rivers, is especially interesting to the morphologist on account of the peculiarities of structure and the habits coincident therewith which it exhibits, and also, more especially, from the fact of its being intermediate between the old-fashioned and the new-fashioned fishes. One of the peculiarities of this fish is the existence of "serrated appendages" or "flagella" beneath the throat, which are attached by their bases to the lateral aspect of the sterno-hyoid muscles. Experiments have been made, under the direction of Prof. R. Ramsey Wright, of University College, Toronto, to elucidate the physiology of these appendages. His specimens of *Amia*, "after being in captivity for some time, became very sluggish, and hardly any movements of respiration could be detected. After the fish had been removed for a little out of the water, however, and then returned to it, the movements were sufficiently active to disclose the following facts:

"During the enlargement and filling of the cavity of the mouth, the posterior flexible (and muscular) border of the gill-opening is tightly applied to the soft parts behind the gill-opening. When the mouth-cavity is quite full, the mouth closes, the muscular border of the gill-cover releases its sucker-like hold of the soft parts, and the water is driven out by the contraction of the walls of the mouth-cavity." (*Science*, v. 4, p. 511.)

Development of the common American Catfish.—Mr. John A. Ryder has published the results of an investigation into the embryology of a common American catfish, the *Amiurus albidus*. The eggs of this species are laid in a large depressed mass, and are adherent together and to the object upon which they are laid. They are about one-eighth inch in diameter and hatch in about six days, when the water is of the temperature usually prevalent during the breeding season of the species, which, about Washington, is in July. The male, after the eggs are laid, faithfully guards the eggs, hovering over them, and fanning the mass of ova with his lower fins, apparently for the purpose of forcing water through them.

Each egg is covered by two envelopes, an inner true zona radiata and an outer elastic adhesive lamina, which is raised up from the inner one upon a series of columns consisting of the elastic substance. It thus results that a space is formed between the inner and outer envelopes of the egg, which is filled with water. The outer elastic envelope permits the male to make comparatively violent movements while renewing the water over the ova without detaching them from one another or from the objects to which they are affixed. Indeed, the elasticity of this outer membrane is surprisingly extensive in the living ova.

On the second day the barbels appear in blunt processes, thus early defining the order to which the embryos appertain. They arise at the

angles of the mouth; then the chin and the nasal barbels make their appearance. All but the nasal barbels, upon examination with the microtome, are found to contain a cartilaginous supporting axis.

The yelk is very coarsely granular and is composed of spheroidal bodies which are more or less misshapen by mutual pressure. At the end of about two weeks the yelk-bag becomes outwardly imperceptible. The peculiarly wide or extended cerebellum of these fishes begins to be apparent at a very early stage in the embryo. The segmentation is meroblastic, a very sharply defined germinal disk being formed. The way in which the embryos swing their tails back and forth within the egg on the second and third days reminds one forcibly of this habit in an angry cat, and is worthy of note on account of the name of this group, viz, the Catfishes.

The young, after hatching, cluster together and seem to follow the male parent. When feeding upon chopped meat the young were frequently taken into the mouth of the male parent, who would, however, always reject his progeny alive and unharmed from his mouth before swallowing, showing that he was able to discriminate between his young and his food. (*Bull. U. S. Fish Com.*, III, pp. 225–230.)

The Saccopharyngidæ relatives of the Eurypharyngidæ.—In the search for relations of the strange Eurypharyngidæ, Messrs. Gill and Ryder became convinced that the genus *Saccopharynx*, proposed in 1824 by Mitchill, and the *Ophiognathus*, named three years later by Harwood (1827), were closely related, and consequently the family embracing the two has been approximated to the Eurypharyngidæ as a related type. Some modifications were also found to be necessary in the diagnosis of the ordinal group. The Lyomeri are now distinguishable as Teleost fishes with five branchial arches, none of which are modified as branchiostegal or pharyngeal, far behind the skull; an imperfectly ossified cranium, deficient especially in nasal and vomerine elements, articulating with the first vertebra by a basiocipital condyle alone; with only two cephalic arches, both freely movable, (1) an anterior dentigerous one (the supramaxillary) and (2) the suspensorial, consisting of only hyomandibular and quadrate bones; without opercular elements; without palatine or pterygoid bones; with the scapular arch imperfect, limited to a simple cartilaginous piece, remote from the skull; with the rays of the pectorals sessile directly upon them, and with separately ossified but imperfect vertebræ.

A peculiar type of Fishes.—Over 100 years ago (in 1781) a very curious fish was described by the German naturalist, Hermann, under the name *Sternoptyx*, but the old naturalist was deceived by appearances and quite misunderstood the structure and relation of the species. Although its anatomy has been worked at, its peculiarities have not been appreciated. Attracted by certain appearances, Professor Gill examined the skeleton and found that it exhibited differences of such a

character as to isolate it from most other fishes. In the typical fishes, generally, the scapular arch is connected with the cranium directly through the intervention of the supra-scapula or post-temporal bones which abut upon the paroccipital bone. In *Sternoptyx* the scapular arch, however, has no connection whatever with the sides of the cranium, but the post-temporal or its homologue advances upwards and meets its fellow of the opposite side and the two abut upon the middle of the cranium or supraoccipital bone behind and at the nape. Consequently the genus is not only the type of the family Sternoptychidæ, but has been taken as the type of a group which may be considered as of ordinal value and to which the name Iniomi has been given. This order includes not only the Sternoptychidæ, but, according to the observations of Mr. John A. Ryder, also the Chauliodontidæ; and quite likely some other fishes which have been confounded with the Scopelidæ and Stomiatidæ may also belong to it.

The Sternoptychids, it may be added, exhibit such differences among themselves as apparently to necessitate a recognition of two sub-families, the Sternoptychinæ and Argyropelecinæ.

The American Mullets.—The true mullets or those constituting the family Mugilidæ, are fishes which are gregarious, moving together in large schools. They have a peculiarly modified and complex pharyngeal apparatus, by means of which they strain the mud in which they chiefly find their food in the form of the microscopical organisms included therein. The family is abundantly represented in the tropical as well as temperate waters, although much less so in the latter than in the former. According to the latest views of ichthyologists, two species ascend on the coasts of Europe to the British waters and even further northwards, and two species likewise reach the American coast as far north as Massachusetts. Messrs. Jordan and Swain have recently investigated the salt-water American species of the family occurring in the temperate as well as tropical waters, and find that in the seas on both sides of the continent there are representatives of three distinct genera, *Mugil*, *Chænomugil*, and *Querimana*.

The genus *Mugil* contains the largest species, and is the one most generally distributed and represented by numerous species throughout the range covered by the family. Six species of the genus are recognized as American, and two of these are very abundant along the southern coast of the United States and form the subjects of a very important fishery. Our two species are now endowed with the names *Mugil cephalus* and *Mugil curema*. *Mugil cephalus* is the designation which it is proposed to adopt for the species formerly known as *Mugil albula*, for it is now declared that the American form is not specifically distinct from the European *Mugil cephalus*. *Mugil curema* is the name substituted for the one generally called *Mugil braziliensis*. The *Mugil cephalus* is the species which has the soft dorsal and anal fins almost

naked, and the sides ornamented with dark longitudinal stripes; it is the largest of the east coast species. The *Mugil curema* has the soft dorsal and anal fins scaly, and the sides are plain and without any dark stripes.

A very little mugilid is quite abundant about Key West and other parts of Florida, and also occurs in Charleston Harbor; it is known as the whirligig, and has been named *Querimana gyrans*.

The American Parrot-fishes.—Under the name of Parrot-fishes are included quite a number of typical fishes distantly related to the blackfish or tautog of the North American waters, but differing in the development and exposure of the jaws and the more or less confluence of the teeth with the jaws, and also by the modification of the pharyngeal bones, which are provided with broad pavement-like teeth. The rays of the fins are very constant in number, there being in the dorsal fin nine spines and ten rays, and in the anal two spines and nine rays. The scales are large and also quite constant in number, there being about 24 vertical rows, of which those ending on the caudal fin are elongated and pointed backwards. The colors are usually quite gay and striking. The fishes themselves are mostly found about coral reefs or in coral groves, and the peculiar character of the jaws and teeth has reference to their habits, the fishes feeding upon the coral, which they bite off and then ingest. They may to some extent be called ruminating fishes, and have a peculiar apparatus exercising an analogous function, as has been lately demonstrated by Dr. Sagemehl. These fishes are well represented in the Caribbean Sea, and have been recently investigated by Messrs. Jordan and Swain. These gentlemen regard the group as a sub-family of the labrids, and recognize for the American species three genera, for which they adopt the names *Scarus*, *Sparisoma*, and *Cryptotomus*. Their nomenclature is somewhat peculiar for the genera. (1) The one called by them *Scarus* is the same as that generally known as *Pseudoscarus*; (2) the *Scarus* of European and most other authors is called *Sparisoma*; (3) the genus generally known as *Calliodon* is also called by a different name, *Cryptotomus*, inasmuch as the former was originally given as a generic name for all *Scaridæ*, but with specific mention of only true *Scari* of Jordan and Swain. The celebrated *Scarus* of the ancients, a well-known inhabitant of the Mediterranean Sea, must now, it seems, be known as a *Sparisoma*, and as congeniers of it in the Caribbean Sea we have eight species; of the genus *Scarus*, five species are recognized by Jordan and Swain, and of the genus *Cryptotomus* only two are known from the West Indies. The species have been neatly defined by Jordan and Swain, and the result of their labors is a substantial addition to systematic ichthyology, and especially the West Indian fish fauna.

The use of the Remora in fishing by Africans.—It has long been known that fishes of the Remora kind, or salt-water "suckers," as they are

called by American fishermen, have been used for fishing purposes, but a recent account by Mr. Frederic Holmwood, the British consul at Zanzibar, adds additional information. It appears that the use of the remoras for fishing is still in vogue in that country. The fishes are mostly kept in small canoes and come to the surface of the water on the approach of the fishermen, and they have learned to allow themselves to be taken from the water and submit to being handled without attempting to plunge or break away. The owners call them with "a soft whistling sound," but Mr. Holmwood had "no means of observing whether this was recognized by the fish." Each fish had a strong iron ring or loop fixed in front of the tail or caudal fin for attaching a line to when it was to be employed in fishing. "In some cases these appendages had evidently remained on for years, during which the fish had so grown that the iron had become embedded in a thick fleshy formation. In two instances the ring had been inserted in the muscular substance at the root of the tail, but generally a simple iron band was welded round the thinnest part of the body a few inches from the tail, which kept it from slipping off. To this was riveted a small movable ring or loop resembling that of a watch-handle. In one case this loop was fastened on by servings of brass wire in a similar manner to the rings of a fishing-rod."

The fishes are taken out by the fishermen on their trips, which, according to Mr. Holmwood, never occupy less than fifteen days. A specimen was brought to him with the ring gone and with a large wound or rent before the tail, part of which was also gone. The owner declared that it had caught two turtles, and that it had afterwards "affixed itself to a large shark, and holding on after all the spare line had been paid out, the tail had given way. He stated that the remora, or, as it was called by the natives, *chozo*, had then relinquished its hold and returned in its mutilated state to the boat." The fishermen assured Mr. Holmwood that "this was not an unusual occurrence, and that after a time a fresh ring would be attached and the fish become as useful as before."

The sucker of one of the specimens examined by Mr. Holmwood had twenty-three pairs of lamellæ, and the species was probably the *Echeneis neucrates*, or slender remora. (*Proc. Zool. Soc. London*, 1884, pp. 411–413.)

Amphibians.

A new family of Toad-like Amphibians.—A toad-like animal was obtained by the British Museum from Mr. H. B. Guppy, which is of interest on account of its distinctness from previously known forms; it inhabits three of the Solomon Islands and presents such peculiar characters that it has been regarded by Mr. Boulenger as the representative of a new family. The species has been named *Ceratobatrachus Guentheri;* the generic name alludes to the development of "a small curved

spine at the angle of the jaws." It belongs to the group of Firmisternia and is related to the other species of the group as the Hemiphractidæ are to the Arcifera. The family named Ceratobatrachidæ in fact is definable as Firmisternials with teeth in the upper as well as lower jaw, cylindrical (non-dilated) sacral diapophyses, and with precoracoids and an omosternum. (*Proc. Zool. Soc. London*, 1884, pp. 212, 213.)

Pugnacity of a Frog.—The frog will appear in a new light to many, through the observation of an English gentleman, Mr. Edwin H. Evans, recorded in Nature. A short time before dark this gentleman heard "a squeaking noise" below his veranda, and on inquiry found that it came from a bat in contest with a frog. The bat was "evidently getting the worst of it, but at last succeeded in getting away for a time from its opponent; the frog again attacked it, but this time *he* was glad to cry 'quits,' as the bat turned on him and beat him off, afterwards managing to hide somewhere," so that he could not be found. The frog was found badly "bitten about the nose, and was in a sad plight." Mr. Evans remarks that the bat had "probably fallen from its nest during the day and was waiting for the evening, when the frog espied it and attacked it, with the before-mentioned result." (*Nature*, XXXI, p. 55.)

Reptiles.

A new group of extinct Jurassic Reptiles.—In Wyoming Territory, in beds of the horizon of the Atlantosaurus beds of the Upper Jurassic, the lower jaw, or rather the dentary bones, of a peculiar reptile were obtained. These are believed by Professor Marsh to indicate a new "order" of extinct Jurassic reptiles, to which he has given the name *Macelognatha.* The bones in question "resemble in many respects the corresponding parts of a turtle, but are broader and more nearly horizontal. The jaws were evidently covered with a horny beak in front, but further back they contained teeth. The edentulous portion is flat and thin, and nearly horizontal. The two rami meet in nearly the same plane, and are united at the symphysis by a close suture." The teeth had fallen out, but their places were indicated by sockets, the walls between which "become thinner backwards, and a groove appears to gradually take their place." Such were the only evidences of the nature of the extinct animal, but Professor Marsh considers that he was justified in assigning to the species (*Macelognathus vagans*) not only a new family name but a new ordinal one. He thought that the "jaws are too solid and massive for birds or pterodactyles," and that "the close union of the rami by suture separates them from Dinosaurs, and the edentulous beak from crocodiles." He surmises that the animal "was nearest allied to the Chelonia, although turtles without teeth occur in the same strata with them." (*Am. Journ. Sc.* (3), XXVII, p. 340.)

New American Dinosaurs.—Professor Marsh has continued his investigations of the American Jurassic Dinosaurs, notices of which have been published in previous numbers of these reports of progress, by the description of a new family of "Sauropoda." A considerable portion of the skeleton of one of the species of the group was exhumed, and it was ascertained that the new family called Diplodocidæ was related to the Atlantosauridæ and Morosauridæ, and distinguished by the following characters:

Sauropodous Dinosaurs with the ischia having straight shafts directed downward and backward, the ends meeting at median line; a large pituitary fossa, and anterior caudal vertebræ deeply excavated below.

Two species of the family have been made known, which have been named *Diplodocus longus* and *Diplodocus lacustris*. The *D. longus* was intermediate in size between the previously known Sauropods, and is supposed to have been about forty or fifty feet long when alive. The teeth show, according to Professor Marsh, that "it was herbivorous, and the food was probably succulent vegetation. The position of the external nares indicates an aquatic life." The remains of the *D. longus* were found in Upper Jurassic beds near Cañon City, Colo., and those of the *D. lacustris* near Morrison, Colo. All of the American Sauropod Dinosaurians, hitherto obtained, have been found in Upper Jurassic rocks, and no Cretaceous forms of this group are known. The group is supposed by Professor Marsh to have the nearest affinities, of all the Dinosaurs, with the Crocodilians. (*Am. Journ. Sci.* (3), XXVII, pp. 162–168, pl. 3, 4.)

United metatarsal Bones in a Reptile.—Last year a Dinosaurian reptile was described as *Ceratosaurus nasicornis*, whose most interesting feature is to be seen in the metatarsal bones. "There are only three metatarsal elements in each foot, the first and fifth having apparently disappeared entirely," while the remaining three had become "completely ankylosed," and very much shorter and more robust than in the other members of the group to which it belongs. In fact, the union of the metatarsal elements in the Dinosaur is as perfect as is that in ordinary birds. The position of the foramen, so characteristic of recent birds, is also the same in the Dinosaur. Professor Marsh summarizes that all known adult birds, "with possibly the single exception of *Archæopteryx*, have the tarsal bones firmly united, while all the Dinosauria, except *Ceratosaurus*, have these bones separate. The exception in each case brings the two classes near together at this point, and their close affinity has now been clearly demonstrated." (*Am. Jour. Sc.* (3), XXVIII, pp. 161, 162.)

The Pteranodous or toothless Pterodactyles.—In 1872 Professor Marsh briefly noticed some remains of reptiles exhumed from middle Cretaceous

rocks of Western Kansas, which were regarded by him as indicative of not only a new family, but a new order related to the pterodactyles, and distinguished by the absence of teeth. His previous communications have been recently supplemented by a well illustrated article on the "principal characters of American Cretaceous pterodactyles," in connection with which he gives figures of the skull and bill from four different views. The skull is certainly very remarkable, and extremely different from those of all the typical pterodactyles; it is much elongated, the facial portion being greatly produced forwards, and a sagittal crest of enormous size, and reminding one somewhat of a helmet, but compressed, extending "far backwards and somewhat upward." The jaws are also quite peculiar and "project forward like a huge pair of pointed shears; they are very long, sharply pointed in front, and entirely destitute of teeth," and indeed the margins are as smooth and thin as in recent birds. It is supposed by Professor Marsh that the jaws were inclosed in a horny sheath. The bones of the skull are mostly extremely thin, and, "with the exception of the occipital condyle, the lower ends of the quadrates all seem to have been pneumatic." A noteworthy feature is the existence of large antorbital openings near the middle of the skull and directly over the posterior nares. The skull is described as having a length of 760 millimeters. Professor Marsh sums up the evidence furnished by the skull with the statement that it differs especially from that of the other pterodactyles "in (1) the absence of teeth; (2) the absence of anterior nasal apertures, distinct from the antorbital openings; (3) the presence of the elongated occipital crest"; and (4) the encasement of the jaws with a horny sheath. (*Am. Journ. Sc.* (3), XXVII, pp. 422–426, pl. 15.)

The classification of Lizards.—The system of the Lacertilian order has been revised by Mr. G. A. Boulenger. Commendation is given of Professor Cope's work on that group as showing the best appreciation of the characters and relationships of the families of the order. Physiognomy and external characters, which were much relied upon by the old naturalists, are of little consequence and very apt to mislead. The anatomical characters and especially the modifications of the cranium are the safest guides and the best clew to the affinities of the animals. The suborders of Professor Cope's system are reduced to two: (1) the Lacertilia vera, and (2) the Rhiptoglossa, including only the Chamæleons. Twenty-one families are recognized; many of these are more or less modified and two new ones established, *Uroplatidæ* for *Uroplatys*, formerly confounded with the geckos, and *Dibamidæ*, based on *Dibamus*, one of the most degraded of the lizards. (*Ann. & Mag. Nat. Hist.* (5), XIV, pp. 117–122.)

The Bull-snake's Voice.—A large and well-known snake, although of local distribution in the United States, and known in New Jersey by

the name of Bull or Pine snake (*Pityophis melanoleucus*) is notorious on account of the sounds it emits. This was described by the old naturalist of Philadelphia, William Bartram, as "a terrible hiss, resembling distant thunder," but there are few who have heard it who would not regard such a description as very much exaggerated. By Dr. Charles A. White, the hiss of the bull-snake is described as having "a peculiar hoarseness which is sometimes so loud that, with the help of the imagination, it appears to have suggested a likeness to the low rumbling bellow of the bull," and in reference to this similarity the serpent owes one of its names. Dr. White has inquired how the sound is produced. He found that it is due to the character and posture of the epiglottis. This organ is absent, or represented only by a tubercle, in all other serpents which he had seen: in the bull-snake it is "a thin, erect, flexible, flag-shaped or curved spatulate body, situated upon the median line immediately in front of the rima-glottidis, and with its free end directed upward and backward, its posterior edge curving partly over the rima. It is evidently this epiglottis that produces the hoarseness of the hissing sound, which it accomplishes by dividing, and fluttering in the strong current of air which is forced from the lung out of the rima." (*Am. Nat.*, XVIII, 19–21.)

Birds.

Coues' Key to North American Birds.—One of the most important books on ornithology published during the past year is the second edition of Coues' "Key to North American Birds," and, in the words of one of the most distinguished of European ornithologists, it is "one of the best and most useful bird-books ever written." The first edition of this well-known work was issued in 1872, and the changes have been so great as to necessitate a thorough revision and recasting of the work. Indeed, the so-called second edition is really a new work, for very little of the old is retained unchanged; to it are added the "Field Ornithology," formerly published as a separate work, and above all a most important introduction on the anatomy of birds in general, in which the osteology, neurology, angeiology, pneumatology, splanchnology, and oology are successively considered. In the words of the European ornithologist, already quoted, "So much information that cannot be got at elsewhere is brought together in this comprehensive treatise, that it ought to be in the hands of every ornithologist, whether he is a special student of the American avifauna or not."

Baird, Brewer, and Ridgway's Water-Birds of North America.—The great work on North American Water Birds, whose completion has been so long and eagerly looked for, has at length been finished. The three volumes on the Land-Birds were published about ten years ago (in 1874)

with the general title "A History of North American Birds," by Little, Brown & Co., of Boston, but, as we are informed in the preface to the Water-Birds, "the cost of the publication of the 'Land-Birds of North America' was so great that the publishers of that work were unwilling to continue it at their risk and expense." At last, Professor Whitney, the former State geologist of California, and Prof. A. Agassiz, the director of the Museum of Comparative Zoology, assumed the cost of publication. The volumes of "The Water-Birds of North America," thus brought out, are nearly uniform with, and the practical completion of, the old "History of North American Birds." A full figure of the bird and figures of generic details in outline illustrate each genus, and the head of each species is also figured. Both colored and uncolored copies are published.

The water-birds are segregated under nine groups, four of waders and five of swimmers. The orders of waders are Herodiones (I, p. 1) with four families, Limicolæ (I, p. 107) with seven families, Alectorides (I, p. 350) with three families, and Phœnicopteri with one family; those of the swimmers are Anseres (I, p. 419) with one family, Steganopodes (v. 2, p. 126) with six families, Longipennes (II, p. 191) with three families, Tubinares (II, p. 344) with two families, and Pygopodes (II, p. 420) with three families. This arrangement was not presented as "strictly natural," but as the most apt at present "for the convenience of the student." It was suggested that "the orders most nearly related are the (1) Herodiones and Steganopodes, (2) Limicolæ and Alectorides, (3) Phœnicopteri and Anseres, and (4) Longipennes and Tubinares. Of the Pygopodes the Alcidæ present many points of true relationship to the Tubinares and Longipennes, while the latter are not far removed from the Limicolæ. The Podicipidæ also appear to resemble in some respects (perhaps only teleological) the Steganopodes."

The most noteworthy features, in the way of novelty in the new work, are the revised groupings of the Tubinarine families, and especially of the family of Albatrosses or Diomedeidæ, the increase in the species of gulls of the family Laridæ, and the arrangement of the family of Alcidæ.

Although published in the same year as Dr. Coues' "Key," the later date of printing and the sudden acquisition of specimens and comparison of all the forms enabled the authors of the Water-Birds to incorporate two additional species of large northern gulls (*Larus Nelsoni* of Henshaw, and *Larus schistisagus* of Stejneger), thereby increasing the number of North American species of the genus (including the *Chroicocephali*) to nineteen.

The large collections of skins of Alcids, or auks, murres, &c., and various data resulting from the experience of Dr. Stejneger, in their homes, threw fresh light on their characters and relationships, and a new arrangement of the entire family was the result, which is here given

in comparison with that retained by Dr. Coues, which essentially expressed the previous views of American naturalists.

I. ALLINÆ.	II. ALCINÆ.
1. Alle.	6. Alle.
II. ALCINÆ.	
(*Alceæ.*)	
2. Plautus.	12. Alca.
3. Alca.	11. Utamania.
(*Uriæ.*)	
4. Uria.	10. Lomvia.
III. PHALERINÆ.	
(*Ceppheæ.*)	
5. Cepphus.	9. Uria.
(*Brachyrampheæ.*)	
6. Brachyramphus.	8. Brachyrhamphus.
7. Synthliboramphus.	7. Synthliborhamphus.
(*Phalereæ.*)	I. PHALERIDINÆ.
8. Ciceronia.	
9. Phaleris.	4. Simorhynchus.
10. Simorhynchus.	
11. Cyclorhynchus.	
12. Ptychoramphus.	5. Ptychorhamphus.
13. Cerorhyncha.	3. Ceratorhina.
IV. FRATERCULINÆ.	
14. Fratercula.	1. Fratercula.
15. Lunda.	2. Lunda.

Miocene Tertiary Indian Birds.—The Tertiary beds of India, belonging to the series of Siwalik beds (so called on account of their being developed in the Siwalik Hills), have furnished numerous remains of mammals, which have been the subject of various elaborate monographs. The bones of birds have also been found in considerable numbers, but have not been investigated until lately. Mr. Robert Lydekker has recently applied himself to the determination of the relationships of these remains, and has been able to prove to his satisfaction that the bones belonged to species of *Pelecanus*, *Phalacrocoax*, *Leptoptilus*, *Mergus*, *Struthio*, and *Dromæus*, or at least very closely related genera. The most interesting is the so-called *Dromæus*. This form, called *Dromæus sivalensis*, has been based upon four phalangeal bones, which so closely resemble those of the living *Dromæus* or emu as to leave little doubt in his mind that they belonged to at least a nearly allied genus of the class, although perhaps generically separable. (*Ibis* (5), III, p. 107.)

Shedding of Claws in Birds.—Long ago Prof. Sven Nilsson, who recently died at a very advanced age, called attention to the fact that in certain species of grouse the claws were periodically shed, but his

and other observations have been generally forgotten of late years. Dr. L. Stejneger has lately had occasion to recall them in connection with new facts discovered by himself, exhibited in a ptarmigan (*Lagopus albus*). He states that in this bird the shedding of the claws "takes place in July or August, according to locality and other circumstances, at the time when the toes are most denuded, in fact almost wholly naked, and the dark summer plumage is most complete. The claws grow very rapidly, however, and reach their full length long before the white winter plumage with the densely clothed toes is fully developed." So far as known, continues Dr. Stejneger, "this process is confined to the members of the family Tetraonidæ," but has been now found in *Bonasa bonasia*, *Urogallus urogallus*, *Lyrurus tetrix*, *Lagopus albus*, and *L. Ridgwayi*. According to Dr. Collett, of Christiania, a specimen of the common quail of Europe (*Coturnix coturnix*) also shed its claws in confinement, but this, says Dr. Stejneger, "may have been due to some pathological process."

As is generally known, the claws of the ptarmigans in winter become much elongated, and Dr. Stejneger quotes some observations of Professor Meves upon the habit of the bird bearing upon this development. The species of *Lagopus* have, "all through the winter, to struggle with the snow, upon which they are forced to walk. The snow is often loose, and, with a foot like that of the common fowl, they would need much greater exertion of their strength in order to keep themselves on the surface. But the ptarmigan, by having the under side of the toes thickly covered with feathers, which can be spread out, and by means of the long and straight claws, which may be compared with snow-shoes, are enabled to run easily over the snow. The usefulness and the necessity of the lengthening of the nails are self-evident. In the genus *Tetrao* (*Urogallus*, + *Lyrurus*, + *Bonasa*) the lateral horny fringes of the toes render the same excellent service, and may fitly be regarded as a kind of snow-shoe. During the summer this whole outfit becomes superfluous, which may be the main cause of the periodical shedding." (*Am. Nat.*, XVIII, pp. 774, 775; *Ibis* (5), III, pp. 50–52.)

The number of Parrots.—A useful work by Dr. Anton Reichenow has been brought to a close, and, as it has been finished, constitutes a monograph of the family of Parrots. It has appeared in 11 folio parts, with 33 colored plates; 448 species of the group are recognized, and thus we have, including species described meanwhile and since, nearly 460 species of that family or group of families. These, some or other, inhabit all the tropical countries and are represented by a few outlyers in both the northern and southern temperate regions. (*Ibis* (4), III, p. 112.)

Light weight of the Hornbill.—Some interesting observations have been published by Prof. Alphonse Milne-Edwards on one of the hornbills (*Calao rhinoceros*). The individual serving for these observations

was taken to Paris by M. F. Fauque, the chief of a scientific mission to Sumatra, sent by the French minister of public instruction. The bird is apparently almost as large as a turkey, but on account of the peculiar disposition of its breathing apparatus and the large air-sacs it is remarkably light; its weight scarcely exceeds 1,500 grammes. (*Comptes Rendus Acad. Sc. Paris*, November 17; *Nature*, XXXI, p. 95.)

Two Swans from one egg.—A remarkable case of the development of two birds from an egg with two yelks has been recorded by Mr. Albert A. C. le Souëf, of Melbourne. A black-necked swan of Australia had commenced sitting on three eggs, but one of them was broken and not replaced by another, leaving only two behind. Nevertheless, to the astonishment of Mr. le Souëf and the keeper, three cygnets came forth from the two eggs. At first the cygnets were nearly of a size, but in a very short time one commenced to grow much faster than the other two, and at the age of seven months one of them was as large as the parents, but the other two very much smaller, although unequal in size, and the smallest was a queer little fellow, and although apparently quite healthy remained covered with down and looked as if it were only two months old. (*Proc. Zool. Soc. London*, 1884, p. 390.)

Mammals.

Tuberculosis in Menagerie Animals.—It has been asserted that a very large proportion of tropical animals, and especially of the monkeys, die in the menageries from consumption—phthisis tuberculosis. The subject-matter has been investigated by Mr. J. B. Sutton, lecturer on comparative anatomy in the Middlesex Hospital Medical College, and his conclusions contradict the views generally current. On a superficial examination, indeed, he says, "it would seem that half the animals dying in the Society gardens succumb to this affection. It so frequently happens that if the lung presents a spotted appearance or on section shows caseous spots of any description, the condition is set down as 'tuberculosis.'" But after careful inquiry, the conclusion was forced on Mr. Sutton that "tubercle is by no means so common among animals as is generally supposed. Three diseases are especially liable to be confounded with consumption, and the latter must be diagnosed carefully. The precision afforded by microscopical examination of diseased tissues has led to a more rigid definition, and consequent restriction, of the term 'tubercle' from such appearances as the lungs present in lobular pneumonia, or lung-tissue consolidated by pneumonia, which, instead of resolving, ends in suppuration, and, lastly, encysted parasites. If these three morbid conditions be excluded, then tuberculosis is *very uncommon.* The larger carnivora (lions, tigers, and leopards) are exceedingly vulnerable to attacks of pneumonia, and bears frequently die from this affection, due to the suppuration of the consolidated portion of the lung. The coati (*Nasua*) is very liable to suffer from cavities in its lungs due to

this breaking-down of inflammatory products, and on three occasions pneumothorax has resulted from the rupture of a vomica." Even encysted parasites may be mistaken for tubercle. After due study of the disease and its conditions, Mr. Sutton reached the conclusion that "the disease had its origin in the food or at least in the alimentary canal," and bacilli were found by "thousands and tens of thousands." The viscera of such animals as had died of consumption exhibited certain lesions, and it was supposed that the disease was due to feeding on fowls that already had consumption. Two animals afforded the means for determining whether such was likely to be the case or not. The two animals were "fed on birds' heads and viscera, and as their livers contained 'bacilli' it was fair to infer that they had accidentally contracted the disease by feeding on tuberculous fowls." But "what the precise nature and origin of these organisms may eventually turn out to be, is of course very uncertain; the matter is still being investigated and must for the present remain *sub judice*." As to the monkeys, tubercle was found only in three cases among 110 individuals that died; of these two were Rhesus monkeys and one a Vervet monkey, all Old World species. In these cases "the disease was unmistakable tubercular phthisis associated with cavities in the apices of the lungs, in every point resembling the disease as met with in the human subject." (*Proc. Zool. Soc. London*, 1884.)

The Monotremes, egg-laying Mammals.—In 1799, Shaw ventured to describe, as a new generic type of mammals, a skin obtained from Australia which combined the body of a quadruped with a bill resembling that of a duck. On account of such a combination, Shaw was at first doubtful whether it was not an artefact, but, seeing no evidence of the handiwork of man, he proceeded, with some hesitation, to describe the object as a new species, giving it the name of *Platypus anatinus*. Very soon after (in 1800), Blumenbach, in Germany, also described a similar specimen under the name of *Ornithorhynchus paradoxus*. The name *Platypus* being pre-occupied, the animal, for such it proved to be, bears now the name of *Ornithorhynchus anatinus*, its validity as a true animal being established. But later, skepticism was awakened on another point. It was affirmed that this animal laid eggs, and, indeed, a couple of anatomists inferred that it did from observations of its genitalia. Inasmuch, however, as all other mammals were supposed to be viviparous, and in such the ovarian eggs are excessively minute, it was thought by many that there must be some error in the observations, or falsification. The assertion was taken up and corroborated later by several observers of the animal in nature, and an egg was even figured by Geoffroy St. Hilaire. Several of the old naturalists, including Charles Bonaparte, on account of its oviparity, regarded it as the representative of a peculiar class intermediate between mammals and birds. A French naturalist claimed to have found a specimen pregnant with young, but skepticism pre-

vailed, and in time not even the remembrance of the facts was left. During the past year, however, the reliability of the old naturalists has been verified by two independent observers, Mr. W. H. Caldwell and Dr. Wilhelm Haacke. Mr. W. H. Caldwell, who, it may be remarked, was the first Balfour student, went to Australia, partly at the expense of the British Association for the Advancement of Science, for the purpose of studying the embryology of the Monotremes and *Ceratodus*. In September a telegram was sent to the British Association informing its members that "Caldwell finds Monotremes oviparous; ovum meroblastic." About the same time Dr. Haacke found an egg in the Australian *Echidna* or *Tachyglossus*. The two animals, however, differ considerably in their disposition of the egg. The aquatic *Ornithorhynchus* excavates a deep hole in the banks, which it enters by an opening under the water, and in its burrow it forms a kind of a nest in which it deposits two eggs. The terrestrial *Tachyglossus* produces only one large egg having an essential resemblance to that of the *Ornithorhynchus*, but transfers it to its mammary pouch, wherein it is hatched.

The statement that the egg is meroblastic, which the telegraph conveyed to the British Association, demands a word of explanation. This means that only a portion of the egg is involved in the original segmentation, and that the rest is a food-supply for the early developing embryo. In other words, the egg resembles that of a bird or reptile, and differs from the minute one of the other mammals.

For other facts in the long and interesting history of the Monotremes the various articles elicited by the new discovery may be referred to. (*Zool. Anzeiger*, December 1; *Science*, v, p. 3; *Science*, IV, p. —; *Nature*, XXXI, pp. 132–135; *Revue Scientifique*, XXXV, pp. 657–659.)

The species of Tachyglossids.—In the early part of the past century a strange spine-bearing mammal of Australia was made known under the name of *Echidna aculeata*, and is now generally known as the *Tachyglossus aculeatus*, the former name having been previously given to a genus of fishes. For a long time it was the only known species of the type, and the genus was supposed to be peculiar to Australia; but within the past decade no less than three species have been obtained from New Guinea, and two of these are so different from the long-known Australian species (and another related one discovered in New Guinea) that they have been generically separated. We have, therefore, now four species, or, if we give specific rank (as some may consider to be most natural) to the form occurring in Tasmania, we have five species of this interesting family. These are as follows:

1. *Tachyglossus aculeatus*, of Southern Australia.
2. *Tachyglossus setosus*, of Tasmania or Van Dieman's Land.
3. *Tachyglossus Lawesii*, of Southern New Guinea.
4. *Zaglossus Bruynii*, of Northern New Guinea.
5. *Zaglossus villosissimus*, also of New Guinea.

It may be remarked here that the name *Zaglossus* was the first given to the genus later called by others *Acanthoglossus*, *Proechidna*, and *Bruynia*. The name was proposed by Gill, in 1876, in the Annual Record of Scientific Discovery.

The skull of a Triassic Mammal from South Africa.—Although quite numerous evidences of the existence of mammals in the Triassic and Jurassic formations have been obtained, that evidence has been chiefly limited to what could be obtained from the lower jaw and the dentition thereof. The discovery of more or less entire skulls is therefore of great interest. Such a find has been made in South Africa in the Trias beds, distinguished by the richness of their reptilian remains. The specimen in question is a nearly entire skull, wanting only the hinder part, and measuring "about 3¾ inches in length from the broken end of the parietal crest to the point of the united premaxillaries. The upper surface shows the anchylosed calvarial portions of the parietals and the frontal bones divided by a suture; the contiguous angles of these four bones are cut off, so as to leave an aperture, occupied by matrix, which may be a fontanelle, or a pineal or parietal foramen. The frontals form the upper borders of the orbits, which are bounded in front by the lacrymal and malar bones, and were not completed behind by bone. Each frontal is narrowed to a point at the suture between the nasal and maxillary. The nasals are narrow, but widen in front to form the upper border of the exterior nostril, which is terminal, and is completed by the premaxillaries. The maxillaries are widened posteriorly, then constricted, and again widened before their junction with the intermaxillaries."

It will be thus seen that Professor Owen has not been able to obtain characteristics of great importance, and the structure of the base of the cranium, the roof of the mouth, and the interior of the skull remains unknown. In fact merely superficial characters have been determined.

The teeth of this form in the upper jaw consisted of a pair of large round incisors, behind each of which was a smaller premaxillary tooth. On each side were six molar teeth, "the first of which has a subtriangular crown with the base applied to the second tooth." The latter and the following teeth are "nearly similar, subquadrate in form, with the crowns impressed by a pair of antero-posterior grooves, dividing the grinding surface into three similarly disposed ridges, and each ridge is separated by cross notches into tubercles. Of these there are in the second to the fourth molar inclusive, four tubercles on the mid ridge, three on the inner ridge, and two on the outer ridge." Between the premaxillary and molar teeth was "a ridged diastema," no canines being developed.

The dentition thus indicated was different from that exhibited by recent forms, resembling that of the *Microlestes* from the Keuper of Würtemburg and the Rhætic of Somersetshire and those of the Oolitic genus *Stereognathus* and the three forms apparently belonged to the same family, the Stereognathidæ.

The dentition of the Capybara.—The Capybara is distinguished by a very remarkable dentition which has impelled some naturalists to recognize it as a peculiar family type—the Hydrochœridæ. The milk-teeth have been lately examined by Professor Flower. The little animal, eight days old, had just the same number of teeth as the adult. "The incisors and four molariform teeth were all present and in an equal state of development. A small portion of the surface of each, including the posterior molar, has been already abraded by wear. The molar teeth show the same form and pattern as in the adult, being each divided by deep lateral grooves into distinct lobes corresponding to those of the full-grown teeth. They are, however, all very much smaller, the length of the whole series in the upper jaw being 30 millimeters instead of 72 as in the adult. They evidently represent the narrow apical portion of the permanent teeth, which, as growth proceeds, wears off, and they are not in any case milk-teeth. As the first of the series, or premolar, is as fully developed as the one which follows it (or first true molar) it must either have no predecessor, or one which has disappeared at an early stage of intra-uterine life." (*Proc. Zool. Soc. London*, 1884, pp. 252, 253.)

A new generic type related to the Musk-rat.—A naturalist would scarcely look for a new generic type of mammals as large as a rat in any part of the United States, and yet such a form was obtained last year by the National Museum and described by Mr. Frederick W. True, the curator of mammals. The specimens were obtained at Georgiana, Fla., by Mr. William Wittfield. The animal resembles an ordinary musk-rat in general appearance, but has neither the compressed rudder-like tail nor the large webbed hind feet and bent toes characteristic of the musk-rat. It looks, indeed, in the words of Mr. True, "like an overgrown and dropsical house-rat, and was at first entered in the catalogue of the Museum," by his assistant, "as a doubtful species of that genus." A closer examination, however, demonstrated that it was very distinct not only from any *Mus*, or the musk-rat, but from any other known mammal. It has the "general form and color," as well as the "head, eyes, and fore-legs," characteristic of the musk-rat, but the hind limbs are less than twice the length of the fore-feet and have "straight slightly webbed toes and naked soles;" the tail is round and very thickly covered with dull-brown hair, through which the scales which encase it are apparent. The length of the head and body is 20.2 centimeters, and that of the tail 12.7 centimeters; the hind-feet (without the claws) are 3.9 centimeters long.

No particulars have been received respecting the habits of the animal, but, in Mr. True's opinion, "the slight webbing of its toes, and their unbent condition, taken together with the rounded tail, would lead one to prophesy that it is not so thoroughly aquatic as the ordinary musk-rat, probably no more so than many of the field-mice." The name *Neofiber Alleni* has been given to the new Murid. (*Science*, IV, p. 34.)

A new suborder of extinct Mammals.—In 1882 Professor Cope described, from a fragment of the lower jaw, a new generic type of mammals under the name *Pantolambda bathmodon*. A considerable part of the skeleton having been since secured, Professor Cope was able to form a more adequate idea of its characters and considered it as the type of not only a distinct family but of a "new" suborder of Amblypoda. The reference is somewhat doubtful owing to the inability of Professor Cope to examine the carpus, but the co-ordination of characters seems to indicate the place claimed for the genus by him. Assuming, then, that the Pantolambdidæ form a peculiar family of Amblypoda, Professor Cope proposes to define and limit the suborders as follows:

The Pantolambdidæ represent the suborder Taligrada distinguished by the "astragalus, with a head distinct from trochlea, with distal articular facets."

The Pantodonta may be known by the astragalus destitute of a head and the distal facets subinferior. (*Proc. Am. Phil. Soc.*, xx, pp. 557–559.)

The acclimatization of the Japanese Deer.—There is a small deer found in Japan, *Cervus sika*, related to the Sambur deer, or Rusa, which may become a subject of some economical importance. The Viscount Powerscourt imported some of these animals and turned them into his park, and had considerable success in raising them. He commenced with one male and three females, and these, Viscount Powerscourt thinks, "have been the only deer of any newly-introduced kind which have been a real success." These deer were introduced about the year 1860, and in 1884 Viscount Powerscourt had "upwards of one hundred of them, besides having shot two or three yearly, and also having given away a great many and sold others." The viscount sums up his opinion that the Japanese deer are "a most satisfactory little deer; the venison when dressed is about the size of Welsh mutton and very well flavored. The little stags, with their black coats and thick necks, like miniature Samburs, are very picturesque and ornamental, and I think they are a decided addition to our varieties of hardy park deer." They have "a most peculiar cry in the rutting season, a sort of whistle, varying sometimes into a scream." The Japanese deer interbred with the red deer in the viscount's park, and there were three or four deer in the park which were regarded as being certainly hybrids, the red hind in each case being the dam.

Early Lemuroids.—The Lemuroids, which are now so characteristic of Madagascar and represented sparingly in other parts of Africa, instead of being peculiar to a limited continent, were in early times widely distributed, and the forms of Africa are really the relics of a once widely-spread type. The old forms, however, were not very closely related to the modern, and represent even distinct families. They were at home in America as well as in Europe during the Eocene, and in late years

much light has been thrown upon their relationship. One was known to Cuvier and indicated under the generic name of *Adapis*. But the great French naturalist had no idea as to its true affinities, and in fact mistook its remains for those of a hog-like animal. In America, according to Professor Cope, two families were represented in the Eocene period, one of which, the Mixodectidæ, had three premolars in the upper jaw, and the other, the Anaptomorphidæ, had two. The Mixodectidæ were represented by as many as five generic types, and of the Anaptomorphidæ, two have been made known. Of the latter, the typical genus is *Anaptomorphus*, and another one has been called *Indrodon*.

The name *Anaptomorphus* has reference to the similarity of the cranium to that of man, while *Indrodon* refers to some similiarity between the dentition of the form so named and that of the extinct Madagascar genus, *Indris*. (*Am. Nat.*, XVIII, pp. 59–62.)

Breeding and disposition of Monkeys and Lemurs.—The extent to which the Primates (monkeys, &c.) may breed in confinement will probably be new to most persons. Mr. Arthur Nichols ascertained that at least twelve out of about eighty species kept in the Zoological Gardens have bred during the past thirty years. Lemurs formed a large proportion. The Rhesus monkey bred more frequently than any other species. According to Mr. Nichols, "the disposition and moral character (in the widest sense) of no species of monkey whatever approaches that of the dog," and he suggests that this may be due to the absence of inheritance of the "gradually accumulated cultivation of these qualities through association with man" which the dog has enjoyed. The monkey cannot benefit by such experience, "owing to the impossibility of rearing a succession of generations in captivity." (*Nature*, XXXI, p. 54.)

Diseases of Monkeys and Lemurs.—The diseases of the monkeys and lemurs have been investigated by Mr. J. B. Sutton, who had special access, for that purpose, to the Zoological Gardens of London. He continued his investigations from December 1, 1881, to March 30, 1883, during which time one hundred and ten of the quadrumana died, and the viscera of ninety-three were specially examined with the following results: (1) tubercle was found in three instances only; (2) bronchitis was met with in twenty-two cases; (3) pneumonia in its lobar form is not common, only three deaths being traced to that disease, but "the lobular form is frequent, seven deaths having been occasioned by it;" (4) empyema was manifested in two cases; (5) "abscess of lung burst into a bronchus, filled the trachea and thus suffocated a baboon;" (6) "œdema of lung killed a squirrel monkey;" (7) alveolar abscess was a not uncommon mode of death in young animals, "leading to ulceration and sloughing of the gums;" the purulent discharges being swallowed, septic pneumonia is established, "sometimes leading to gangrene of the lung;" (8) scrofula was well marked in three cases; (9) "intussusception of the

jejunum killed a very fine lemur;" (10) leucocythemia was met with in a lemur, "the spleen of the animal having become enlarged to fifty times the normal bulk;" (11) "typhoid fever proved fatal in four cases, three lemurs and one monkey."

A "very unexpected cause of death manifested itself in bone disease, in the form of typical rickets. Next to bronchitis this is the most frequent cause of death among the monkeys." For a detailed clinical account reference must be made to Mr. Sutton's original communication. (*Proc. Zool. Soc. London*, 1883, pp. 581–586.)

A new fresh-water Manatee.—It has recently been shown that not only is there a difference between the African and American Manatees, but that there are two species of the genus represented along the American coast, one being that of Florida and the other found along the South American coast. Still more recently, the mammals collected many years ago by Dr. Natterer, the Austrian naturalist, so well known for his travels in Brazil, have been worked over by Dr. Von Pelzeln, who has now charge of the collections in Vienna of which the old traveller's gatherings form a part. It seems that among them were found specimens of a manatee that lives high up the Amazon as well as the Rio Negro, the Rio Brancho, and Madeira. It is stated that Natterer himself had perceived the differences between this manatee and the others that are known, and had given it the name *Manatus inunguis*, referring to its nailless fingers. The specific distinction of the form has been insisted upon by Dr. Von Pelzeln, and the animal has been fully described. (*Am. Nat.*, XVIII, p. 941.)

The flukes of Whales.—What are the flukes of whales? This, it appears, is a question that cannot be satisfactorily answered at the present time, and at least there is a diversity of opinions in respect to their homologies. Do they simply represent a laterally expanded tail, or are they the remnants of the posterior feet of quadruped ancestors? A difference in interpretation has long prevailed, and the subject has been made prominent recently by some memoirs or addresses of Prof. W. H. Flower. By some old naturalists, and even by Linnæus, the flukes were regarded as tantamount to the entire hind limbs. Not long ago, Gill suggested that the flukes represent the hypertrophied integuments of the hind limbs, while the osseous portions partially persist in the rudimentary bones located far in front of them. Lastly, Professor Flower has again taken up the question. "One of the methods," says he, "by which a land mammal may have been changed into an aquatic one is clearly shown in the stages which still survive among the carnivora. The seals are obviously modifications of the land carnivora, the Otaria, or sea-lions and sea-bears, being curiously intermediate. Many naturalists have been tempted to think that the whales represent a still further stage of the same kind of modifications. But there is to my mind a fatal objection to this view. The seal, of course, has much in common with the whale,

inasmuch as it is a mammal adapted for an aquatic life, but it has been converted to its general fish-like form by the peculiar development of its hind limbs into instruments of propulsion through the water, for, though the thighs and legs are small, the feet are large and are the special organs of locomotion in the water, the tail being quite rudimentary. In the whales the hind limbs are aborted and the tail developed into a powerful swimming organ. Now, it is very difficult to suppose that when the hind limbs had once become so well adapted to a function so essential to the welfare of the animal as that of swimming, they could ever have become reduced and their action transferred to the tail. It is far more reasonable to suppose that whales were derived from animals with large tails, which were used in swimming, eventually with such effect that the hind limbs became no longer necessary, and so gradually disappeared. The powerful tail, with lateral cutaneous flanges, of an American species of otter (*Pteronura Sandbachii*), or the still more familiar tail of the beaver, may give some idea of this member in the primitive cetacea."

Such are the arguments, in brief, of Professor Flower. But it is not necessary to suppose that the whales have evolved from a specialized form like the Pinnipeds, which he indeed denies, for he rather contends that they show ungulate affinities. It appears to be more reasonable to infer that the cetaceans have descended from quadrupeds with rather weak or ordinary hind limbs. Nevertheless, we find, in the feet of the Otariids, or eared seals, some clew to the possible genesis of the flukes as modifications of the limbs.

Let us suppose, then, that a terrestrial mammal with even ordinary (but not ungulate) hind limbs should take to the water, and its descendants, following it in habits, should develop processes analogous to the membranous extensions of the hind limbs in the eared seals. These may be employed in swimming, and the osseous parts not assisting, or even being prejudicial to such progress, might become atrophied, and in the course of atrophy would be overgrown by the integument and muscles, and appear to be pulled forward, while the membranous portions of the feet would become hypertrophied; this hypertrophy would extend to the muscles as well as to the integuments, and, of course, all would become very much modified. In fine, we would in time have a case where the posterior limbs of the ancestral quadruped would be represented in part by the flukes and in part by the included rudimentary bones, the flukes representing the hypertrophied integuments of the primitive members and the bones the atrophied remains of the skeletal portions. The fact that in the *specialized* aquatic or rather pelagic forms, the tail is always very much reduced or rudimentary, may be considered as entitled to some value as an argument in favor of the view presented, although not much. The transversely expanded tails of the South American otter and beaver are quite exceptional. In most aquatic forms, the tail is more or less compressed.

NECROLOGY OF ZOOLOGISTS, 1884.

BODINUS (*Dr.* HEINRICH), director of the Zoological Garden of Berlin, died November 23, 1884, at Berlin; born at Drewelow in Pomerania, July 29, 1814.

BREHM (*Dr.* ALFRED EDMUND), a well-known German ornithologist, died November 11, 1884, at Renthendorf; born in 1829.

FAHRAEUS (O. J.), an entomologist, died May 28, 1884, at Stockholm, in the 88th year of his age.

FITZINGER (*Dr.* LEOPOLD JOSEPH), a zoologist, especially an author in Mammalogy and Herpetology, died September 22, 1884, at Hietzing, near Vienna; born April 13, 1802.

FÖRESTER (*Prof. Dr.* ARNOLD), an entomologist, died August 13, 1884, at Aachen (Aix-la-Chapelle).

JEFFREYS (JOHN GWYNN), a conchologist, died January 21, 1885, at London; born at Swansea, January 18, 1809.

KEFERSTEIN (D. A.), a well-known entomologist, died November 28, 1884, at Erfurt.

KÖSTLIN (*Prof. Dr.* OTTO), an anatomist, died September 1, 1884, at Stuttgart.

RÜPPELL (*Dr.* WILHELM PETER EDWARD), a celebrated traveler and zoologist, died December 11, 1884, at Frankfort; born November 20, 1794.

SMITH (SIDNEY), an entomologist and conchologist, died December 28, 1884, at Walmer, in the 80th year of his age.

SOWERBY (GEORGE BRETTINGHAM), a well-known conchologist and paleontologist, died July 25, 1884, at London; born March 2, 1812.

THOMSON (*Prof. Dr.* ALLEN), a very able anatomist and physiologist, died March 21, 1884, at London; born at Edinburgh, April 2, 1809.

TÖMÖSVÁRY (*Dr.* E.), an entomologist, died August 25, 1884, at Budapest.

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ANTHROPOLOGY.

By Otis T. Mason.

INTRODUCTION.

The summary of progress in Anthropology for 1884 will contain the titles of many illustrious works in every department of the science.

The programme of anthropology has been admirably sketched by Professor Flower in his anniversary address before the Anthropological Institute of Great Britain and Ireland.

"One of the great difficulties with regard to making anthropology a special subject of study and devoting a special organization to its promotion, is the multifarious nature of the branches of knowledge comprehended under the title. Anthropology, as now understood, treats of mankind as a whole. It investigates his origin and his relations to the rest of the universe. It involves the aid of the science of zoölogy, comparative anatomy, and physiology; and the wider the range of knowledge met with in other regions of natural structure, and the more abundant the terms of comparison known, the less risk there will be of error in attempting to estimate the distinctions and resemblances between man and his nearest allies, and fixing his place in the zoölogical scale. Here we are drawn into contact with an immense domain of knowledge, including a study of all the laws which modify the conditions under which organic bodies are manifested. Furthermore, it is not only with man's bodily structure and its relation to that of the lower animals that we have to deal: the moral and intellectual side of his nature finds its rudiments in them also, and the difficult study of comparative psychology is an important factor in any complete system of anthropology.

"The study of 'prehistoric archæology,' as it is commonly called, investigates the origin of all human culture, endeavoring to trace to their common beginning the streams of all our arts, customs, and history, knowledge of the origin and development of particular existing customs, throws immense light upon their real nature and importance, and, conversely, it is often only from a profound acquaintance with the present, or comparatively modern, manifestations of culture that we are able to interpret the slight indications afforded us by the scanty remains of primitive civilization. Even the more limited subject of ethnology must be approached from many sides, and requires for its

cultivation knowledge derived from sciences so diverse, and requiring such different mental attributes and systems of training as scarcely ever to be found combined in one individual. The differential characters of the groups or races of mankind, are:

"1. Structural or anatomical characters.

"2. The mental and moral characters by which races are distinguished.

"3. Language.

"4. Social customs, including habitations, dress, arms, food, ceremonies, beliefs, laws.

"The subject of ethnography, or the discrimination and description of race characteristics, is perhaps the most practically important of the various branches of anthropology."

The following works of general import were issued in this country during the past year:

"The Second Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution, 1880–'81, by J. W. Powell, Director," this year issued from the Government press, bearing the date of 1883. The volume is uniform in appearance with the first, and contains xxxvii–477 pages, 77 plates, 714 figures, and 2 maps. The following is the table of contents: Report of the Director, pp. xv–xxxvii; Zuñi Fetiches, by F. A. Cushing, pp. 9–46; Myths of the Iroquois, by Erminnie A. Smith, pp. 47–116; Animal Carvings from the Mounds of the Mississippi Valley, by H. W. Henshaw, pp. 117–166; Navajo Silversmiths, by Dr. Washington Matthews. pp. 179–306; Art in Shell of the Ancient Americans, by W. H. Holmes, pp. 185–305. Catalogue of Collections, &c., by James Stevenson, pp. 307–422; Catalogue of Collections, by James Stevenson, pp. 425–466.

The Director's report reviews the work of the Bureau, with comments upon the papers published in the volume.

Mr. Cushing discusses the subject of fetiches in general, but devotes the most of his paper to a very interesting explanation of the hunter gods of the north, south, east, west, above, below.

Mrs. Smith's chapter is a collection of Iroquois myths, taken partly from literature, but mostly from the lips of the Indians by the writer.

Mr. Henshaw reviews the works of Squier and Davis, as a naturalist, to show that the suggestions of the mound pipes and other carvings existed in the Mississippi Valley, and none of the animals represented are tropical.

Dr. Matthews, while serving on the frontier, employed a Navajo silversmith to make some jewelry, watching him, and reporting every step in the process.

Mr. Holmes's paper relates especially to the use of shells by the ancient mound-builders, the most interesting chapter being devoted to carved gorgets resembling in ornamentation Aztec specimens.

Colonel Stevenson gives an account of a year's collecting, his catalogue being illustrated with numerous cuts.

The American Antiquarian continues to be the only periodical in America devoted entirely to a department of anthropology.

The Sixteenth and Seventeenth Annual Reports of the Trustees of the Peabody Museum, forming Nos. 3 and 4 of Vol. III, contain the following anthropological papers:

Sixteenth report of the curator.

List of additions to the museum and library.

Social and political position of women among the Huron-Iroquois tribes, by Lucien Carr, assistant curator.

Human remains from caves in Coahuila, Mexico, by C. A. Studley.

The White Buffalo Festival of the Uncpapas, by Alice C. Fletcher.

The Elk Mystery of the Ogallala, by Alice C. Fletcher.

Ceremony of the Four Winds, by the Santee Sioux, by Alice C. Fletcher.

The Shadow or Ghost Lodge, an Ogallala ceremony, by Alice C. Fletcher.

The Pipe Dance of the Omahas, by Alice C. Fletcher.

Seventeenth report of the curator, with lists of additions.

Report on Meteoric Iron from Mounds, by R. P. Kennicott, Ph. D.

The curator's report gives a flattering account of the work of the museum in 1884. In addition to the usual appropriation the sum of $3,350 was subscribed for archæological research in America.

Professor Putnam gives a *résumé* of successful explorations in the shell-heaps of Maine and in the mounds of Tennessee and Ohio. The explorations at Madisonville, Ohio, especially, were of the most thorough character, and the results were in many respects new to American archæology.

Mr. Carr takes the ground that woman among the Huron-Iroquois Indians was not the drudge she is commonly represented to be, but had only her fair share of labor, and great influence in the councils of the tribe.

Miss Studley gives an account of the osteological collections from four caves in the limestone formation in the State of Coahuila, Mexico, collected in 1880 by Dr. Edward Palmer.

Miss Fletcher describes the festival given to the man who among the Uncpapas has the good fortune to kill a white buffalo; the Santee ceremony of seeking the black stone or the raven; symbols of the four winds; and the Ogallala-Sioux custom of keeping a ghost lodge for deceased kinsfolk.

By far the most important things found by Professor Putnam, in the altar of the Turner mound, were several pieces of meteoric iron and ornaments made of this metal. Dr. Kennicott gives an analysis of this iron at the close of the report.

M. Désiré Charnay published in a quarto volume the results of his explorations under the patronage of Pierre Lorillard.

The international geographical exposition at Toulouse included an anthropological section, with the following subdivisions:

(1) *Anthropology.*—Crania, skeletons, anatomical preparations, figures, and busts.

(2) *Demography.*—Statistics, graphic methods, charts, &c.

(3) *Prehistorics.*—Human remains, quaternary fauna and flora, arms, utensils, &c., charts, books, reproductions, views, &c.

(4) *Ethnology and ethnography.*—Lay figures, illustrations of the origin, crosses, character, cults, manners, and industries of peoples.

(5) *Linguistics.*—Geographical distribution and filiation of languages, patois, books, globes, charts, tables.

(6) *Societies.*—Publications, apparatus of demonstration, programmes of courses, instructions, plans of museums and laboratories.

The Academy of Natural Sciences in Philadelphia has created a chair of ethnology and archæology, and appointed Dr. Daniel G. Brinton professor.

Two works continue to be issued from the Surgeon-General's Office in Washington of which the value is incalculable to anthropologists—the Index-Catalogue and the Index-Medicus. The former is a classified list of the literature in the great library of the Surgeon-General, and the latter is a monthly classified bibliography of the medical literature of the world.

Three volumes in the series of H. H. Bancroft appeared: the first of the history of California forms volume XVIII of the series; the first and second of the history of the Northwest Coast form volumes XXVII and XXVIII of the series.

The Dictionnaire des Sciences Anthropologiques completed its first volume, and two numbers of the second volume appeared during the year.

"In Russia," says L'Homme, "there are eight universities: Petersbourg, Moscow, Kief, Kharkof, Kazan, Odessa, Dorpat, and Varsovie. The professors number 385. Among the chairs lately created in each university there is to be a professor of geography and ethnography."

Among the English visitors at the British Association in Montreal was Prof. E. B. Tylor, who took occasion to visit Washington and the Pueblos. Three addresses were delivered by Mr. Tylor, all of them worthy of thoughtful attention, upon sociological topics in aboriginal and civilized America.

THE ORIGIN OF MAN.

No progress seems to have been made during 1884 towards settling the question of the place, time, or conditions of man's origin. The conference of the anthropological section of the Association Français at Blois reveals a multiplicity of opinions, not only respecting the discoveries of Abbe Bourgeois, but M. Mortillet has wrested the case altogether from human hands and given it to *Anthropopithecus.* This

will not do; the word was pre-empted by Blainville for a genus of Simiinæ, and we should rather say *Pithecanthropos*. But what *ignis fatuus* are we pursuing that becomes man or ape, according as geologists say man shall or shall not appear in the Miocene? If the flints of Thenay are artificially wrought, that is man's work, whether it was done in Eocene or post-Pliocene. Even then we are far from the first man, who did not imbibe knowledge of flint dressing with his mother's milk.

ARCHÆOLOGY.

A permanent contribution to archæological and proto-historic literature is the work of Dr. Charles Rau, on prehistoric fishing, forming part of Vol. XXV of the Smithsonian Contributions to Knowledge. The author divides his treatise into two parts, the first relating to Europe, the second to America. An appendix gives extracts from the early writers, Egede, Crantz, Lloyd, de Laet, de Champlain, Sagard Theodat, Le Jeune, Charlevoix, Henry, Hearne, Mackenzie, Williams, Johnson, Ogilby, Josselyn, Vander Donck, Kalm, Morgan, Loskiel, DeBry, John Smith, Beverly, Lawson, Brickell, Adair, Du Pratz, Wyeth, Catlin, Powers, Stone, Dunn, Swan, Meares, Captain Cook, and Captain King.

In the discussion of European fishing, a chronological order is followed. Of the Palæolithic Age, the drift period furnishes no relics of fishing implements, the cave period contributes fish-hooks, harpoon-heads, and fish remains. The Neolithic and the Bronze Ages, in all their periods, are rich in the evidences of great activity in this industry. The second part of the volume, relating to North America, is divided into chapters by subjects: Fishing implements, boats, and appurtenances; prehistoric structures connected with fishing; representations of aquatic animals on pipes, &c.; and artificial shell deposits.

In the month of November, 1883, some workmen brought to Dr. Anton Fritsch, from the clay behind the brewery at Podbaba, near Prague, the remains of a human skull. It was taken from undisturbed brick clay (loess) two meters thick, lying under one meter of dense loam, and at the same level at which, about a week previously, a tusk of the mammoth had been obtained. The skull consists of the frontal bone, the whole left parietal, a fragment of the right as well as a part of the left temporal bone, with the petrous. The comparison of this skull with a modern normal one reveals a low arch, a forehead slope of 56°, strongly developed eyebrows, as in the Neanderthal skull. In the layer above that containing this skull are found skeletons and artefacts of the Bronze Age, while in the loess occur remains of the mammoth, *Rhinoceros tichorhinus*, reindeer, and horse. Professor Schaaffhausen is of the opinion that there is not enough of the skull remaining to justify definite conclusions.

The horse has been so long associated with man that its history is considered to be necessary to a study of human environment. The horses, which constitute the genus *Equus* of Linnæus, and are the sole

representatives of the family *Equidæ*, fall into two subgenera, *Equus* and *Asinus*. Of the subgenus *Asinus* the best-known species are (1) the wild ass of Upper Nubia (*Equus tæmopus*), probably the origin of the domestic ass; (2) the wild ass of Persia and Kutch (*E. onager*); (3) the hemippe, or wild ass of the Syrian desert (*E. hemippus*); (4) the kiang, or wild ass of Thibet (*E. hemionus*); (5) the quagga (*E. quaggá*) of South Africa; (6) the Burchells zebra (*E. burchelli*) of Southern and Eastern Africa; (7) the zebra (*E. zebra*) of Southern Africa. No recent species of horse referable to the subgenus *Equus* was known until Prjevalskey on his third great journey to Central Asia brought back to St. Petersburg an example of a new species of wild horse. This animal was described in 1881 in a Russian journal by J. S. Poliatow and named *Equus prjevalskii*. There are some asinine characteristics about the animal, but the preponderance of characters is towards the horse. (*Nature*, August 21.)

Miss Frances E. Babbitt has succeeded in shifting the interest with regard to glacial man from New Jersey to Minnesota. The investigation was conducted with the greatest care, and the result now depends upon two considerations; the geological age of the bed, and the human workmanship upon the objects.

The report of Mr. Bandelier upon his archæological studies among the pueblos of New Mexico in 1881 was printed during the year, and is a permanent contribution to our literature upon that subject. His results are based upon careful and extended measurements.

The Stone Age in China is a new inquiry, and should lead to good results. Mr. Mark Williams announces that from Kalgan to Yücho, 100 miles south, are ancient mounds in clusters on the plain, or singly on eminences. They are about 30 feet high, circular or oval in shape. At Kalgan is a group of forty mounds. The Kalgan mounds, 110 miles west of Peking, have been investigated by Dr. Joseph Edkins.

The Marquis de Nadaillac follows up his volume on prehistoric America with a compilation of what has been written upon the antiquity of man on our continent, and an essay on the latest writings respecting the mound-builders and the modern Indians. But the most remarkable production of the last-named topic is that of Dr. Emil Schmidt on the mound-builders and their relation to modern Indians, published in Kosmos (Leipzig). In the same line are the papers of Carr, Henshaw, Thomas, Royce, and Brinton.

The first volume of the celebrated work, *Mexico á traves los Siglos*, was prepared by Alfred Chavero. The volume comprises the ancient history from prehistoric times till the capture of the city of Mexico by Hernan Cortés, and is composed of the following parts:

Introduction: Comprising a review of all the sources of Mexican history, and an extensive bibliography of Mexican and foreign works on its antiquities, and on all the unpublished hieroglyphics and manuscript documents which are known.

Book 1.—*Prehistoric times:* Comprising anthropological researches, cosmogonic traditions, the autochthonic race, the origins of civilization in the south and in the north, *i. e.*, "*maya-kiche*" and "*naoha*," primitive monuments, languages, religions, customs, &c.

Book 2.—The "*Meca*," comprising the various emigrations of this period, the change of civilization, &c.

Book 3.—The "*Tolteca*," comprising the history of all the contemporaneous nations, the new civilization, new customs, new monuments, &c.

Book 4.—The "*Mexica*," comprising the Aztec migration, the history of the Anahuac people, and of the nations related to them, with a special treatise on their sociology.

Book 5.—Greatness and downfall of Mexico, comprising the Conquest.

Two works on Japanese prehistoric archæology appeared in 1884, composed, printed, and illustrated by natives. The impetus to this work was first given by Professor Morse in his explorations among the Omori shell-heaps. The two volumes just mentioned arrest the attention both by the similarity of humbler forms and ornamentation with the same classes in America, and by the existence of higher forms quite different from American. If this has any bearing upon the question of ethnic contact, it speaks against rather than for the theory. (See "Jijima" and "Kanda" in the bibliography.)

BIOLOGY.

The final agreement of the German anthropologists upon a method of cranial measurement has been reviewed during the year by Dr. J. G. Garson. After a careful study of the code, the conclusion is reached that the importance of the following measurements (numbered the same as in the text of the agreement) has been recognized, and the method of making them is now agreed upon generally:

2. Maximum length.
4. Maximum breadth.
5. Maximum frontal breadth.
7. Height (basio-bregmatic).
10. Basio-nasal length.
12. Length of foramen magnum.
13. Breadth of foramen magnum.
15. Fronto-occipital arc.
17*a*. Bi-jugal breadth.
18. Bi-zygomatic breadth.
18*a*. Interorbital breadth.
21. Height of nose.
22. Breadth of nose.
23. Orbital breadth.
25. Orbital height.
30. Basio-alveolar length.

The following measures are deemed unsatisfactory:

1. Horizontal length.
6. Total height.
8. Ear-height.
9. Auxiliary ear-height.
11. Basilar length.
13*a*. Bi-mastoid width.
13*b*. Breadth of skull-base.
16. Transverse vertical arc.
17*b*. Infra-jugal face-width.
24. Maximum horizontal orbital breadth.
26. Vertical height of orbits.
27. Palatal length.
28. Palatal breadth.
29. Posterior palatine breadth.
31. Profile angle.

At the fourteenth general meeting of the German Anthropological Society, Dr. Johannes Ranke presented a bronze skull which counterfeited as near as possible the human cranium, and could be subjected to the same measurements. Moreover it could be filled with water, and its exact contents determined. Copies of this bronze skull were sent to the most distinguished cranioscopists throughout the world, for the purpose of testing their methods.

At the fifteenth meeting in Breslau, some of the results of various cranio-metric processes were reported as follows:

The true cubage of the bronze skull is 1,316.4 cubic cemtimeters.

Number of measurement.	Von Hölder (with beads).	Schaaffhausen (with millet).	Virchow (small shot).
1 (minimum)	1,311	1,300	1,300
2	1,312	1,305	1,310
3	1,317	1,305	1,320
4	1,319	1,315	1,320
5	1,319	1,315	1,320
6	1,320	1,315	.....
7	1,320	1,320	.....
8	1,321	1,320	.....
9	1,321	1,320	.....
10 (maximum)	1,323	1,325	.....
Average	1,318.2	1,314.3	1,314.0
Minimum	1,311	1,300	1,300
Maximum	1,323	1,325	1,320
Difference	+1.8	−2.1	−2.4
Do	−7.2	−16.4	−16.4
Do	+6.6	+8.6	+3.6

Dr. Emil Schmidt and Dr. Johannes Ranke subsequently measured a bronze skull, whose true cubage is 1,344.5 cubic centimeters, with the following result:

J. Ranke.—Millet in 2,000 cubic centimeter vessel.

1	1,340	
2	1,340	
3	1,345	
4	1,347	
5	1,350	
Average	1,344.4	difference ... −0.1
Minimum	1,340	difference ... −4.5
Maximum	1,350	difference ... +5.5

E. Schmidt.—Shot with Broca's method. Schmidt's adaptation 1,337–1,338. Dif. —6.5 to —7.5 without adaptation. Minimum 1.421; difference 76.5 cubic centimeters.

Dr. Ranke made five experiments with the bronze skull by Broca's method, giving average 1,345.3 cubic centimeters, minimum 1,343.3, maximum 1,347. This was the best result of all.

The British Association Anthropometric Committee.—In 1875 the British Association appointed a committee on anthropometry, of which Dr. William Farr was chairman until 1878. The reports of the committee are as follows: 1878, 5 p., Annual Report 182–6; 1879, 35 p., *ibid.* 175–209; 1880, 41 p., *ibid.* 120–159; 1881, 48 p., *ibid.* 225–272; 1882, 3 p., *ibid.* 278–280; 1883, final report, 54 p., separate. The points to which inquiries were addressed are: 1, stature; 2, weight; 3, chest girth;

4, color of eyes; 5, color of hair; 6, breathing capacity; 7, strength of arm; 8, sight; 9, span of arms; 10, size and shape of head; 11, lower limbs; 12, measures of other parts of the body. These measures were applied to the different elements of the mixed population of Great Britain and compared with those of other parts of the world. The stature is shown in the following table:

Race or nationality.	Authority.	Meters.	Feet and inches.
Polynesian. Samoa 1.853	La Perouse	1.762	5 9.33
Polynesian. Tahiti and Pitcairn 1.782	Garnot, Beechey		
Polynesian. Marquesas 1.763	Porter, Cook, &c		
Polynesian. New Zealand 1.755	Various		
Polynesian. Polynesians 1.758	Wilkes, Novara		
Polynesian. Sandwich 1.731	Lesson, Rollin		
English professional class	Anthrop. Com	1.757	5 9.14
Patagonians 1.778	Musters	1.754	5 9.00
Patagonians 1.730	D'Orbigny		
Angamis (Naga hills)	Woodthorp	1.754	5 9.00
Negroes (Congo)	Topinard	1.752	5 8.95
Scotch	Anthrop. Com	1.746	5 8.71
Amakosa Kaffirs	Sir A. Smith	1.741	5 8.50
Iroquois Indians	Gould	1.735	5 8.28
Todas (Nilghiries)	Marshall	1.727	5 7.95
Negroes (Calabar)	Topinard	1.727	5 7 95
North American Indians	Baxter	1.726	5 7.93
Irish	Anthrop. Com	1.725	5 7.90
United States whites	Baxter	1.719	5 7.67
English	Anthrop. Com	1.719	5 7.66
Norwegians 1.727	Beddoe	1.719	5 7.66
Norwegians, immigrants, United States 1.717	Baxter		
Zulus	Roberts	1.707	5 7.19
English laborers	Anthrop. Com	1.705	5 7.08
Canadians, United States, French immigrants	Baxter	1.703	5 7.01
Tajiks of Feyhana and Samarkand	Ujfalvy	1.705	5 7.10
Swedes, United States, immigrants	Baxter, Beddoe	1.700	5 6.90
Chippeway Indians	Oliver	1.700	5 6.90
Kabyles	Topinard	1.699	5 6.85
Welsh	Anthrop. Com	1.695	5 6.66
Danes, United States, immigrants	Baxter	1.694	5 6.65
Dutch, United States, immigrants	Baxter	1.693	5 6.62
American negroes	Baxter	1.693	5 6.62
English, United States, immigrants	Baxter	1.692	5 6.58
Hungarians	Baxter	1.692	5 6.58
English Jews	Anthrop. Com	1.692	5 6.57
Germans, United States, immigrants	Baxter	1.691	5 6.54
Swiss of Geneva	Dunant	1.688	5 6.43
Swiss, United States, immigrants	Baxter	1.687	5 6.38
Russians, United States, immigrants	Baxter	1.687	5 6.38
Belgians	Quetelet	1.687	5 6.38
French, United States, immigrants	Baxter	1.683	5 6.23
Poles, United States, immigrants	Baxter	1.682	5 6.20
French upper classes	De Quatrefages	1.681	5 6.14
Germans	Novara	1.680	5 6.10
Mexicans	Baxter	1.680	5 6.10
Berbers of Algeria	Topinard	1.680	5 6.10
Arabs	Various	1.679	5 6.08
Usbeks of Ferghana and Samarkand	Ujfalvy	1.679	5 6.08
Javanese	Novara	1.679	5 6.08
Persians	Shulz	1.678	5 6.04
Italians, United States, immigrants	Baxter	1.677	5 6.00
South American immigrants	Baxter	1.675	5 5.90
Australians (aborig.)	Various	1.669	5 5.68
Austrian Sclaves	Novara	1.669	5 5.68
Galchas, Iranian mountaineers	Ujfalvy	1.668	5 5.66
Spaniards, United States, immigrants	Baxter	1.668	5 5.66
Berbers of Algeria	Topinard	1.666	5 5.62
Portuguese, United States, immigrants	Baxter	1.663	5 5.43
Ainos	Rosky	1.660	5 5.33
Austrian Germans	Novara	1.658	5 5.27
French working classes	De Quatrefages	1.657	5 5.24
Eskimo, North America	Various	1.654	5 5.10
Hungarian (military statistics)	Scheiber and Beddoe	1.652	5 5.04
Caucasians	Shortt	1.650	5 4.93
New Guinea	Various	1.646	5 4.78
Hindoos	Shortt	1.645	5 4.76
Bavarians	Novara	1.643	5 4.68
Ruthenians	Majer and Kopernicki	1.640	5 4.54

Race or nationality.	Authority.	Meters.	Feet and inches.
Dravidians	Shortt	1.639	5 4.54
Cingalese	Davy	1.638	5 4.48
Austrian Roumanians	Novara	1.631	5 4.37
Chinese	Novara	1.630	5 4.17
Italian conscripts 1.620	An. di Statist. 1879	1.626	5 4.00
Fuegians	Novara	1.625	5 3.96
Polish jews	Mayer and Kopernicki.	1.623	5 3.88
Poles	Mayer and Kopernicki.	1.622	5 3.87
Finns (Beddoe, 5 feet 5.81 inches)	Novara	1.617	5 3.69
Papuans	Various	1.606	5 3.20
Japanese	Mrs. Ayrton	1.604	5 3.11
Aymaras, Peru	Forbes	1.601	5 3.00
Peruvians	D'Orbigny	1.600	5 3.00
Cochin Chinese	Finlayson	1.593	5 2.70
Malays	Raffles, Crawfurd, &c.	1.583	5 2.34
Veddas of Ceylon	Bailey	1.536	5 0.42
Lapps	Horch	1.500	4 11.2
Andamanese	Man	1.492	4 10.7
Aëtas	De Quatrefages	1.482	4 10.3
Semangs	De Quatrefages	1.448	4 9.0
Mincopese	De Quatrefages	1.436	4 8.53
Bosjesman	Various	1.341	4 4.78
Differences between the tallest and the shortest		.421	1 4.55
Average stature of man		1.658	5 5.25

One of the most important contributions to ethnic anatomy during the year is that of Prof. W. H. Flower, on the size of teeth as a character of race. As a test of the size of the teeth, the length in a straight line (as measured with a sliding compass) of the crowns of the five upper molar teeth, *in situ* between the anterior surface of the first pre-molar and posterior surface of the third molar, is called *dental length* (*d*). The standard of length, as indicating the general size of the cranium, is the cranio-facial axis (B N), the distance between the nasion (naso-frontal suture), and basion (middle of anterior ridge of foramen magnum). In the average male skull the length is very nearly 100^{mm}; in the female, 95. Between the basio-nasal length and the dental length an index can be established on the formula $\frac{d \times 100}{\mathrm{B\,N}}$ = *the dental index.* The average indices range from 40–48; general average, 43. The following series will be convenient in the study of races:

Microdont, below 42.

Mesodont, between 42 and 44.

Migadont, above 44.

Professor Fowler's table for the apes is as follows:

Animals.	B N	d	Index.	Average, both sexes.
Male gorilla, average of 3.	124.0	63.0	50.8	54.1
Female gorilla, average of 3	108.7	63.3	57.3	
Male chimpanzee, average of 3	96.7	46.0	47.6	47.9
Female chimpanzee, average of 3	88.3	42.7	48.1	
Male orang, average of 4	109.2	58.0	53.1	55.2
Female orang, average of 2	90.0	51.5	57.2	
Male siamang, 1	79.0	33.0	41.7	

Races.	Sex.	Number of observations.	Average B N.	Average d.	Average index.	Average both sexes.
MICRODONT RACES.						
British	♂	20	100.0	41.0	41.0	41.8
Do	♀	13	95.0	39.5	41.6	
Mixed Europe, not British	♂	52	101.3	41.0	40.5	41.1
Do	♀	14	95.1	39.6	41.6	
Ancient Egyptians	♂	7	101.4	41.4	40.8	41.0
Do	♀	8	95.9	39.5	41.2	
Polynesians, chiefly Sandwich Islands*	♂	22	105.3	42.2	40.1	......
Low Caste, Central and Southern India	♂	42	99.5	41.2	41.4	......
MESODONT RACES.						
Chinese	♂	12	98.8	42.1	42.6	......
American Indians of all parts	♂	31	99.2	42.5	42.8	......
Malays, Java, Sumatra	♂	70	99.7	43.2	43.3	......
African negroes of all parts*	♂	44	103.0	44.5	43.2	43.9
Do	♀	26	97.9	43.6	44.6	
MEGADONT RACES.						
Melanesians of various islands	♂	21	102.3	45.2	44.2	......
Andamanese †	♂	9	94.4	41.9	44.4	45.5
Do	♀	8	88.8	41.2	46.5	
Australians	♂	22	102.5	45.9	44.8	45.5
Do	♀	14	95.5	44.0	46.1	
Tasmanians	♂	9	100.0	47.5	47.5	48.1
Do	♀	4	95.5	46.5	48.7	

* This index is reduced by the length of basis cranii.
† The relative, not the actual, size of teeth makes them Megadont.

Mr. Nathaniel Alcock has advanced a curious theory about the blackness of the tropical man. The gist of this theory is, that the pigment of the negro skin offers an impediment to the undue excitation of the nervous system by the actinic rays of light.

Considerable interest has been excited by a physiological paper of Dr. Clevenger upon the disadvantages of the upright position. Assuming that man once progressed on all fours, it is shown that the valves in the veins facilitated the return of blood to the heart. But in the upright position there are certain veins in which such return is rather impeded, producing hemorrhoids and other disorders.

One of the most practical investigations now going on is that which essays to bring into some relation measurement of the living and of the skeleton. Dr. Paul Topinard, while finding the most satisfactory agreement between these two measures, has discovered that in some respects, notably in the nasal index, the living subject gives better ethnic results.

PSYCHOLOGY.

Comparative psychology has received an important addition in the efforts of Sir John Lubbock to teach a dog to understand card language and to communicate his wishes in the same manner. Dr. P. A. Chadbourne, of New York, has revived the study of what is called instinct in animals, comparing it with the mental powers of man. The scrutiny of

animal mind is useful to the comparative psychologist in two ways: It enables him to trace the dividing line between human thinking and animal thinking, and it affords the opportunity of watching the movements of thought in its humblest manifestations. Another very fertile field of anthropological study is child mind. Mr. T. S. Clouston publishes in Edinburgh Health Society's Journal, a paper on the growth and development of a child in body and mind. Again, the Italian psychologists excel in the study of the delinquent classes—examining their brains especially to find out what are the anatomical concomitants of depravity and insanity, and also, if possible, to approach the cradle of our race.

But really, psychology is a science of the future. The Society for Psychical Research devotes its time to ghosts, spirit rappings, mind reading, rhabdomancy, &c. This is well enough, and such things as exert an influence on masses of people should be studied. But the society for psychical research that we would encourage is one in which thousands, or at least hundreds, of individuals should sit down beside the simplest mental phenomena until they understand them. No doubt good results will come from the study of telepathy, and Science does well to publish the account of all such researches. The American Naturalist also continues to publish in a separate department the manifestations of animal intelligence.

ETHNOLOGY.

E. F. im Thurn contributes to *Timehri* many interesting articles on the ancient inhabitants of British Guiana. His greatest work is a volume entitled "Among the Indians of Guiana," in which the following tribal names occur:

	Branch or stock.
Ackawoi	Carib.
Amaripas	Wapiana.
Arawaks	Arawak.
Arecuna / Arecuma	Carib.
Atarois	Wapiana.
Caribisi / Caribs	Carib.
Carinya Caribs, call themselves *people*.	
Cobrungrus, hybrids between Indians and Negroes.	
Daurais, same as Atarois.	
Engaricos, hybrids between Macusis and Arecunas.	
Kapohn Ackawois, call themselves *people*.	
Lokono Arawaks, call themselves *people*.	
Macusi	Carib.
Maiongkongs beyond the British border.	
Maopityans, unclassed.	
Nikarikarus, hybrids between Macusis and Brasilians.	
Paramona / Partamona, sub-tribe of Ackawoi	Carib.

Pianoyhotto, sub-tribe of Macusi	Carib.
Piriana beyond the British border.	
Pshavaco, hybrids.	
Taruma, common vocabulary with Moapityans.	
Taurais, same as Atarois.	
Waccawai, same as Ackawoi.	
Wapiana	Wapiana.
Warrau	Warrau.
Woruma, hybrids.	
Woyowai, only the name is known.	
Zurumutas, sub-tribe of Macusi	Carib.

Bessels has made an interesting addition to our knowledge of the Eskimo in his chapter on the northernmost inhabitants of the earth, whom he calls the Itanese.

The opinion is gaining ground that the present Eskimo are the survivors of a very ancient stock once spread much farther south on this continent, and, according to some, dwelling in the caves of France. Professor Dawkins is commonly regarded as the apostle of this theory, and has published a paper in *Nature* upon the subject.

Dr. Otto Stoll's volume on the ethnography of the Republic of Guatemala is an excellent guide-book to the tribes of that country. Comparative vocabularies are given, as well as a colored chart showing the tribes, and a dissected chart exhibiting the affiliations of the different branches of the stock.

Von Hellwald's Natural History of Man has added twelve numbers during the year. Prof. A. H. Keane has brought this work to the notice of English readers in his appendices to Sanford's Compendiums.

The same gentleman contributes to *Nature*, of January 24, 1884, a paper on the Egyptian Sudan and its inhabitants, an abstract of which is given below. Sudan is the Arabic equivalent of Nigritia (Negroland). Its sections are:

(1) *Western Sudan.*—The basins of the Senegal and Quovra-Bénue (Niger).

(2) *Central Sudan.*—The basins of the Komaduga and Shaw, with lands draining into Lake Chad.

(3) *Eastern Sudan.*—East of Waidai, the Upper and Middle Nile Basin, now known as Egyptian Sudan.

The provinces formed out of this territory in 1882 were:

West Sudan.—Darfur, Kordofan, Bahrel-Ghazal, and Dongola, with capital Fasher.

Central Sudan.—Khartum, Senaar, Berber, Fashoda, and the Equator (Hat-el-Istwa), with capital Khartum.

East Sudan.—Taka, Suakin, and Massowah, with capital Massowah.

Harrar.—Zeyla, Berbera, and Harrar, with capital Harrar.

The following is Mr. Keane's ethnologic chart:

Race.	Main divisions.	Localities.
Hamites*	*Tibbu:* Baele, Zoghawa, Wanyanga	North and Northwest Darfur.
	Bishari (Beja): Hadendoa, Hallenga, Ababdeh, Beni-Amer.	Between Red Sea and Nile, 15°–25° north.
	Danokil: Adaiel, Dahimela, &c	Between Abyssinian coast, 10°–15° north.
	Saho, Bogos, Habol	Massowah district.
	Somali: Idur, Isa, Miljarten, &c	Gulf of Aden coast.
	Galla (Orma): Yeju, Wollo, Mecha, &c	East and south of Gojam.
Semites †	*Arab:* Kababish, Sheygieh, Robabat, &c	W. f. Nile, between Dongola and Khartum.
	Homran, Rekhabin, Alawin	Senaar.
	Homran, Hamr, El-Homr, Habanieh, &c	Korfodan and Darfur.
	Ziaieh, Bahemid	North Darfur.
	Himyaritic: Tigré, Dembela, Lasta	North and East Abyssinia.
	Harrari	East from Shoa.
Nubia ‡	*Barabra* (mixed): Kenus, Mahasi, Dongolawi.	Nile Valley, Egypt to Old Dongola.
	True Nuba: Kargo, Kulfan, Kolaji, Jebel Nuba, Tumali.	Kordofan.
	Fur: Fur, Konjara, Fongoro, &c	Darfur.
	Sub-Nuba: Takruri	Gillibat.
	Barea, Basé (Kunama)	Taka, Mareb Valley.
	Funj: Hamagh	Senaar.
Negro §	*Sudanese:* Birkit, Masalit, Abu-sarib, &c	Darfur.
	Nilotic: Shilluk, Dinka, Nuer	White Nile and B. el Arab.
	Fallaugh, Kumkung, Ninak, &c	Sobat Basin.
	Krej, Bongo (Dor), Mittu (Moro)	About west tributaries of White Nile.
	Bari, Madi, Lur, Latuka	B. el Jebel, north of L. Albert Nyanza.
Bantu ‖	Waganda, Wanyoro, Wasoga, Wagamba	Extreme south frontier, north side of L. Victoria Nyanza.

* *Hamite, Kushite* of some writers, answering to the African division of the Mediterranean or Caucasic anthropologic type. For the removal of Tibbu from the Negro to the Hamite race, see *Nature*, March 1, 1883 (North African Ethnology). Most of these are zealous Muhammedans.

† The Arab Semites are recent intruders, mainly via Isthmus of Suez and Egypt. The Himyarites are intruders from prehistoric times from South Arabia via Strait of Bab-el Mandeb. The former Muhammedans, the latter monophysite Christians.

‡ *Nubas*, intermediate between the Negro and the Hamite. *Speech*, Negro. No connection with the Fulah of West Sudan. The Kordofan Nubas, original stock, Pagans. Those of the Nile, Negroid Christians from V–XIV century. Since then mild Muhammedan. They are the Uana of Egyptian records; *Nubæ* of Strabo, later Nubatæ.

§ Most of these negroes still Pagans. Some, as Mittu, Krej, and Bongo, red-brown, rather than black, but the type is negro. Speech of all except the Dinka shows grammatic gender.

‖ Bantus not reduced. Included in the Moudirie de l' Équaeteur of Messedaglia's official "Carte du Sudan" (Khartum, 1883).

Prince Roland Bonaparte is conferring a lasting benefit upon science by his portfolios of racial types. Each person is taken in profile and in full face, and a short biography is in most cases attached.

COMPARATIVE PHILOLOGY.

In the philological camp during the past year there was little activity. Neither the Smithsonian Institution, the Bureau of Ethnology, the Peabody Museum, the Antiquarian Society, nor the Archæological Institute published a paper or a volume on language. Aleman's Quiché Grammar, Brinton's Grammar of the Cakchiquel, Campbell's Khitan Studies, Charency's Maya-Quiché papers, Gatschet's Substantive Verb in North American Languages, and Powell's Classification of North American Languages are about all that might be called permanent literature upon our side of the Atlantic.

The last-named paper is a compilation of the labors of all past inves-

tigators, supplemented by the critical study of the best linguists and the original investigations of the author. Excepting a small part of our west coast, we are now able to refer every square league of our territory to some linguistic stock, and to declare to what stock each tribe belonged. In round numbers there are, or were, within the territory of North America seventy stock languages, each spoken in one or more separate tongues or languages, and each of these ofttimes divided into several dialects.

Dr. Allain's investigations concerning the first rudiments of infantile language open up a wonderful vein of inquiry, leading not only to the study of order in the production of sounds, but to the psychological manifestations revealed in the process.

The development of language among children is the subject of a paper by M. Sikorsky.

Tolmie and Dawson have prepared a volume of comparative vocabularies of the Indian tribes of British Columbia, with a map illustrating distribution. The stocks from north to south are the Thlinkit, Tshimsian, Haida, Kwakiool, Kawitshin, Aht, Bilhoola, Selish, Tinné, Tshinook.

Prof. John Campbell, of Montreal, has continued his investigations upon the probable relationship between the Aztec and other American aboriginal languages and the Khitan.

Through the studies of Brinton, and Charency, the knowledge of the Central American languages has advanced. Brinton especially has made solid contributions to knowledge by the addition of new material.

Mr. Robert Needham Cust has published in two volumes, with a map, a sketch of the modern languages of Africa. It is a work of the greatest value, albeit in some places the author confounds blood and language. The work is reviewed in *Nature* by Mr. A. H. Keane, and the defects are pointed out. It is just such work as preceded the formation of our own Bureau of Ethnology, which will sift the evidence and give us an accurate account of linguistic stocks.

MYTHOLOGY AND FOLK-LORE.

Mr. J. O. Dorsey has made two contributions to the literature of Indian mythology. Several other myths have been recorded. The Bureau of Ethnology is especially engaged in this work, and will publish a large volume on the subject.

Mr. Cushing's paper on Zuñi fetiches, before mentioned, is an account of the deities presiding over space, of the animal forms in which these deities are embodied, the manner in which they are represented in stone, and the conceptions which underlie their worship of these animals.

Major Powell, in commenting on this paper, uses the following language:

"The philosophy of the Zuñis is an admirable example of that stage in

savagery where a transition is shown from zoötheism into physitheism, with survivals of hekastotheism. In this stage fetichism is the chief religious means of obtaining success and protection. The fetiches most valued by the Zuñis are natural concretions or eroded rock-forms, having an obvious or fancied resemblance to certain animals, or objects of that nature in which the evident original resemblance has been heightened by artificial means. It is supposed that these fetiches are actual petrifactions of the animals represented by them, which retain their vital forces for certain magic powers and religious purposes. This belief is explained in a remarkable epic, metrical and sometimes rhythmical, and filled with archaic expressions, which is in part translated by Mr. Cushing.

"A noticeable point in the paper is the elaborate and systematized relationships shown among and between the animals, the animal gods, and other supernatural beings having animal or combined animal and human personalities. This constitutes a theistic society with an elaborate hierarchy and regulated domains, powers, and obligations. Such minuteness in multiformity, as well as the precision of the beliefs and ceremonials stated, will be surprising, not only to persons who have been taught the old fiction of the Indian's monotheism, but to those who have regarded his religious philosophy to be vague and chaotic. The facts are presented with the same corroboration of etymologies in language used so successfully by scholars in the study of Eurasian myths, and with further verification by objects figured in the illustrations."

Folk-lore is a term applied to the learning or philosophy of unlettered people. Long before the systematic, recorded, multiplied observation of phenomena, people come to have a body of sayings about them. There is lore about the weather, medicine, every human occupation. Observe, also, that this lore may be concerning the causes and effects of phenomena, commonly expressed in the words, "That will make it do this or that"; or it concerns natural concomitancy, when we say, "That is a sure sign of something happening." This folk-lore among savages runs into mythology, or lore about spiritual beings, the unseen forces of phenomena. For this reason societies of folk-lore spend much of their labor in gathering what might be called the unwritten bibles of peoples, rather than in the saving of their books of practical wisdom or lore. It will be observed, also, that writers on lore are not careful to discriminate between cause and effect. When they write about flower-lore, for instance, we are not sure whether they mean the lore about what flowers will do or are the signs of, or lore about causes and signs relative to the growth of flowers, or, finally, all the lore in which flowers occur in any connection.

The greatest praise is due to those anthropologists who spare no pains in gathering the lore of the lowly and uncivilized peoples. The English people are far in the lead in this matter, although America, peopled by all races from all lands, offers a most inviting field.

SOCIOLOGY.

Sociological studies in our country have been pursued in two directions. Under the supervision of Major Powell the study of Indian sociology has been prosecuted with great thoroughness. Chief among the students in this line are Major Powell himself and the Rev. J. Owen Dorsey, the former devoting himself more especially to the philosophical side of the question, the latter to the phenomenal side. One of the most interesting inquiries connected with these investigations, relates to those influences internal and external to the tribe which have led from mother-right to father-right. Similar researches have been carried on among Australian tribes, and reported in the Journal of the Anthropological Institute in Great Britain. The other direction which sociological studies have taken is that which leads to the customs prevailing in the early communities of Europeans settling within our territory. These studies have been prosecuted especially under the patronage of the Johns Hopkins University. Mr. C. Letourneau has given much attention to the definition and limits of sociology and the relation of race to social structure.

A popular work of more than ordinary interest is the account of the snake-dance of the Mokis, written by Captain Bourke, U. S. A., from his personal observations.

The sociological studies of Dr. Ploss have become famous through his great work upon the treatment of children among savages, entitled, "Das Kind im Brauch und Sitte." During the year he published another volume, of no less interest and importance, upon the Wife. These subjects are worked out with true German scrupulosity. The works abound in reference to authorities.

The ingenuity of Francis Galton was not exhausted by his invention of composite photographs. During 1884 he devised not only family and life history albums, but set up anthropometric laboratories. It is said that when he could not persuade the people to be measured, he secured his end by charging them a shilling for the privilege, carefully preserving the stubs of the printed record furnished to each visitor.

TECHNOLOGY.

The examination of the bibliography accompanying this paper reveals the fact that there is a technical side to every investigation. There are certain tools of all human activities, be they food-quest, fabrication of clothing or shelter, amusement, social life, or religion. Each tool and each process has had its life history. The study of the life history of tools and their functions is comparative technology. Mr. Simmonds of London has published a dictionary of useful animals, with their products. The collectors for the Smithsonian Institution have spared no pains in obtaining the vulgar and scientific names of the animals and plants entering into domestic economy of savages. A very complete

investigation in aboriginal technology is a short paper in Major Powell's Second Annual Report, on Navajo silversmiths, by Dr. Washington Matthews. It is impossible to tell when this art of metal-working was introduced among the Navajos. It is well known that the Navajos are related to the Tinné Indians of British America, a stock well advanced in artistic conceptions. Coming southward into contact with people acquainted with primitive metallurgy, this natural bent would make it easy for them to practice this art. Their tools and methods are of the most primitive character, and yet some of the works which they produce are of great beauty.

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Uses of the emblematic mounds. Stephen D. Peet.

The lineal measures of the semi-civilized nations. D. G. Brinton.

Description of the skeletons and skulls found in the large mound of the Turner group. Miss C. A. Studley.

The sacred pipes of friendship. Frank LaFleche.

Some observations upon the usage, symbolism, and influence of the sacred pipes of fellowship among the Omahas. Alice C. Fletcher.

Notes upon some quartz objects from Central Minnesota. Miss F. E. Babbitt.

The importance of the study of primitive architecture to an understanding of the prehistoric age in America. Stephen D. Peet.

Local weather lore. Amos W. Butler.

Some characteristics of the Indian earth and shell mounds on the Atlantic coast of Florida. Andrew E. Douglass.

The manner in which Indians made their stone implements. P. R. Hoy.

Disputed points concerning Iroquois pronouns. Erminnie A. Smith.

The use of the plow in Japan. Edward S. Morse.

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PAPERS RELATING TO ANTHROPOLOGY.

ANTIQUITIES AT PANTALEON, GUATEMALA.

By Lieut. CHARLES E. VREELAND, U. S. N.,

and

J. F. BRANSFORD, Passed Assistant Surgeon, U. S. N.

Some 28 miles from the Pacific, on the railroad from San José to the city of Guatemala, the town of Escuintla is situated in a piedmont belt of extremely fertile land. In the same belt, about 30 miles from Escuintla in a northwesterly direction, is the magnificent estate of Pantaleon, within one league of Santa Lucia.

This neighborhood was brought to the attention of archæologists a few years ago by the discovery of the very interesting antiquities at Santa Lucia which were studied and drawn by Dr. Habel, who wrote a paper for publication by the Smithsonian Institution. Several of the finest of these specimens were removed to Berlin, where an account of them was published by Professor Bastian.

The result of the interest thus awakened was the further discovery of great numbers of relics of the old inhabitants in that vicinity.

In 1882 Dr. Bransford visited this locality in the interest of the Smithsonian Institution, and saw some most interesting figures at Pantaleon, a slight account of which he furnished for the Smithsonian Report of 1882.

At the request of Professor Baird, the United States steamer Hartford stopped at San José, July 31, 1884, and we were allowed to visit Pantaleon for the purpose of photographing the antiquities. The superintendent of the estate, Don Miguel Garcia Salas, informed us that the objects had never been photographed, but drawings had been made and photographs taken from them at Guatemala.

The objects were all of black basalt or hard lava. Nos. II, III, IV, and V, the small heads in Fig. 1, were mounted on a low wall around the fountain in the court-yard. Just to the rear and center of these

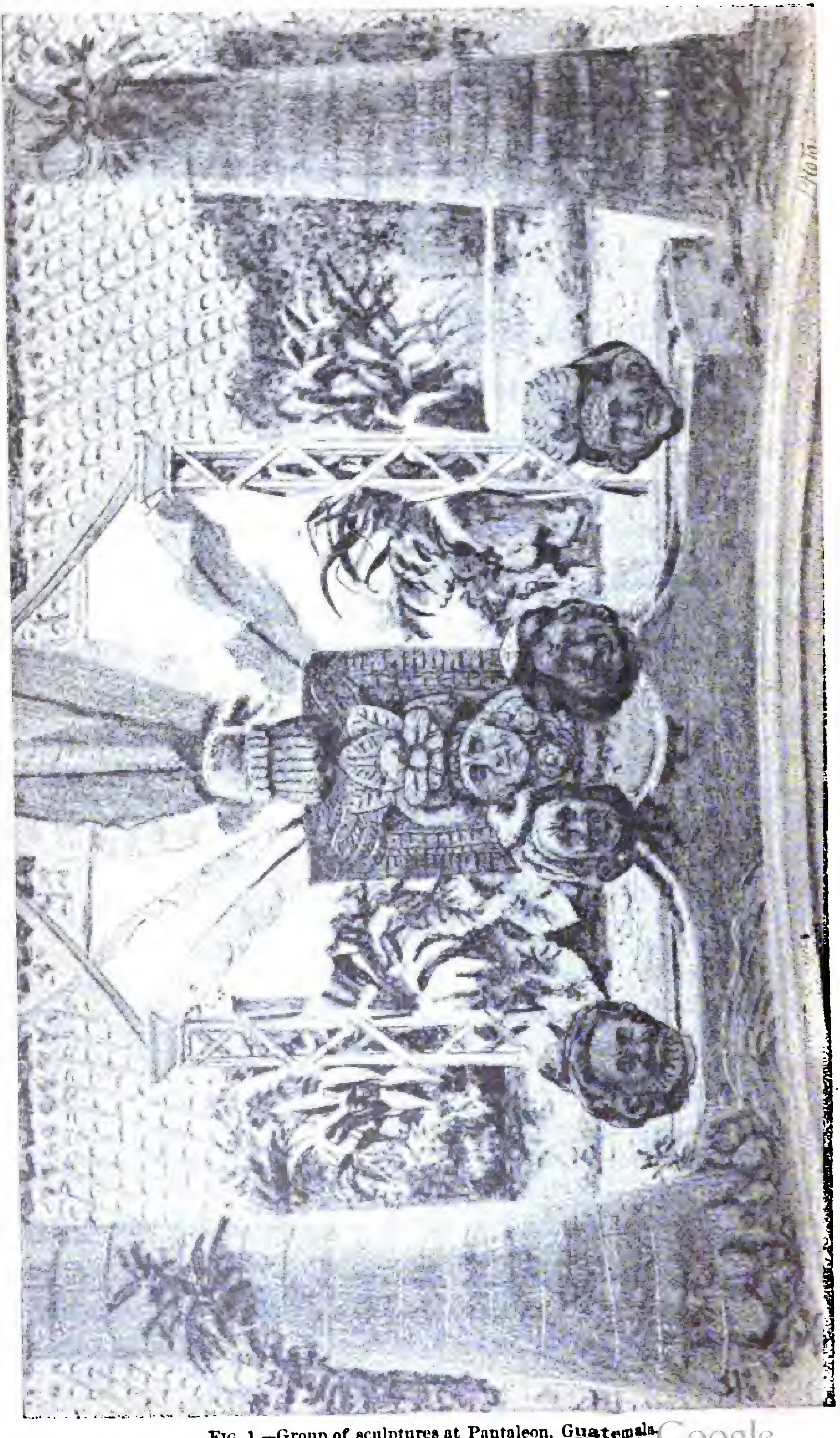


FIG. 1.—Group of sculptures at Pantaleon, Guatemala.

FIG. 2.—Sculpture from San Juan, near Pantaleon, Guatemala.

FIG. 3.—Quarter view of Fig. 2, San Juan, near Pantaleon.

FIG. 4.—Side view of Fig. 2, San Juan, near Pantaleon.

was the grand figure, No. I (Fig. 2), on a pedestal, while No. VI was fixed in the wall of the court, behind No. I. Originally there projected from the lower back part of each head a sort of tenon, which was probably inserted into a wall supporting the figure. This projection is partially shown in Figs. 7 and 9.

Far the finest of these objects in size and workmanship was No. I, shown in Figs. 2, 3, and 4. This was found in a low mound on a hill in the hacienda San Juan, about 7 miles northwest of Pantaleon. Señor Salas informed us that a sculpture similar in size and design, but not in such good condition, was left at the mound. The figure was in high relief, fronting a tablet 50 inches high, 43 wide, and 9 in thickness. A crest rose 17 inches from the upper edge of the tablet, making the total height of the object 67 inches. It was in a state of excellent preservation, the only serious defect being the loss of the greater portion of the nose. The quiet strength and simplicity of the face is something new in the art of the ancient Americans. It was well formed, the lines simple and clear cut, and without a shadow of the conventional. Majesty was so plainly stamped on the countenance that it was known by the Indians as El Rey—The King. The brow, the eyes, and the nose, as far as could be judged, were in good shape and proportion. The mouth was hard and the chin firm and full of character.

On the head was a turban with a banded edge, coming well down on the brow. On the front of the turban an elaborate arrangement of plumes was secured by a double band, knotted in front. Lying on its left side, supported by the band, was a mask of a human face nearly half the size of that of El Rey. This mask, the ear-rings, and the gorget suspended by the necklace were probably chalchihuitls, as we may well imagine that a man of his consequence would naturally choose the favorite green stone wherewith to adorn his person. As a background for the mask was apparently a broad leaf—it was too broad to have been a feather—supported in turn by two others of similar design. These may have been beaten gold, worked into the form of broad leaves or plumes. Behind these and mounting well above, on each side, were long plumes. If the last were furnished by that royal bird the *quetzal*, our cazique surely rejoiced in a head-dress which in gorgeous brilliancy left nothing to be desired.

From the lower edge of the turban, behind the ears, depended braided folds, as of cloth, which mingled with the banded ornamentation on the chest. From the lobe of each ear was suspended a medallion-shaped object, and a larger gorget was supported by the necklace. Around the neck and upper chest other circular ornaments were apparently fastened to the dress.

The tablet had ornamented bands and lines near the sides, but there was no appearance of hieroglyphs. From the upper margin arose a sort of crest, which curved over to the front and ended in a tasseled arrangement pendent above the head. The appearance of the tablet

and crest suggested the back of a chair of state. On the rear surface a fresh cut nearly 3 feet square showed where the tenon had been removed.

The head No. II, Fig. 5, was that of an old person, whose venerable appearance was heightened by the deep lines on brow and cheek. Nearly the whole of the ear was taken up by the cylindrical ornaments. The head-dress ended below in a fluted band, above which, in front, was the body of a bird. The tail and most of the body of the bird had been broken away, but the outstretched wings remained to give evidence of the nature of the cap.

FIG. 5.—Sculpture from Pantaleon, Guatemala.

The extreme height of No. II was 21 inches. No. III, Figs. 6 and 7, was another head of an old person, but instead of the calmness of the preceding face there was depicted the inexpressible sadness of age with blindness. Both eyes were represented as hanging from the sockets, the balls resting on the cheeks. The chin and lower lip protruded, the upper lip fallen in as from loss of teeth. To the long ears were appended large, pear-shaped ornaments. The head-dress was arranged in braided folds, turban-like, with a little Tam O'Shanter cap on top.

This specimen was 18½ inches high.

FIG. 6.—Sculpture from Pantaleon, Guatemala.

FIG. 7.—Side view of Fig. 6, Pantaleon.

FIG. 8.—Sculpture from Pantaleon, Guatemala.

FIG. 9.—Sculpture from Pantaleon, side view of Fig. 8.

FIG. 10.—Sculpture from Guatemala, quarter view of Fig. 8.

Figs. 8, 9, and 10, full, three-quarter, and side views of the head No. IV, show what was probably the most strongly characteristic face of the lot. The prominent brow and cheek-bones, aquiline nose, and well-formed chin were here given their full effect, as in this one figure the nose was complete. The right eye was hanging from its orbit; around the mouth and eyes were few but deep wrinkles; and between the eyes the skin was drawn into two heavy perpendicular folds, giving an expression of agonizing pain.

The few simple lines by which this effect was produced showed in the artist real strength, far removed from the elaborate but fantastic style of conventional Copan.

The long ears were probably exaggerated in size by the heavy ornaments in the lower lobes. The head-dress was arranged in folds, and secured by a band, marked with longitudinal and transverse lines, which passed behind the ears and under the chin, well back against the throat. On the upper left side was an elaborate bow, on which was a circular ornament with graven outlines of eyes, nose, and mouth. On top and a little to the left side of the head a small cap was jauntily placed. The cap was one feature in the *tout ensemble* which gave this more the look of a woman's head.

The height was 23 inches.

The object of the sculptor in portraying these eyes as hanging from their sockets is rather puzzling. It has been suggested that tearing out the eyes was a mode of punishment among the ancients. But it required long time and much labor to carve one of these heads in hard stone, with the tools at their command, and it does not seem likely that such honor would have been shown to criminals. Don Manuel Herrera thought that the fact that eye complaints were prevalent in that section should be considered in the study of this subject. It seems as likely as not that these were representations of individuals whose misfortune was depicted in the sculptures, the artist adopting this mode of indicating blindness.

FIG. 11.—Sculpture from Pantaleon, Guatemala.

In No. V, Fig. 11, we again had the head of an old man.

There were wrinkles on the venerable face around the mouth and eyes and particularly strong on the brow. The supraorbital region and cheek-bones were prominent, the mouth firm, and the large nose was aquiline in form. The tip of the nose was broken.

In front and on top of the turban-like arrangement on the head a broad sash or band was tied in a double bow-knot, the ends widening and falling behind and to the lower edge of the ear on each side. The

little cap on the vertex was pretty well demolished. The beard-like arrangement on the chin may have been intended to represent a chin-strap as it passed up behind the ear-rings, and was apparently continuous with the head-dress.

This is one of the most striking of the faces, and in a general collection would suggest the patriarch of Western Asia. Its height was 21 inches.

FIG. 12.—Sculpture from Pantaleon, Guatemala.

Fixed into the wall of the court, behind El Rey, was No. VI, shown in Fig. 12. It was the roughest of the specimens, and without peculiar features. The ear-rings were large, and on the cap a broken surface showed where was probably a knot, as on No. IV.

Lying in the court-yard was a rough representation of the head of a wild-cat, and a skull somewhat similar to those in Habel's drawings from Santa Lucia and others at Copan.

These figures in simplicity and strength differ from all specimens of ancient American sculpture we have seen pictured or described. They stand as far apart from the grim statues of Nicaragua as from the fantastic and hieroglyph-covered monoliths of Copan, and surely deserve the careful consideration of American archæologists.

THE GUESDE COLLECTION OF ANTIQUITIES IN POINTE-À-PÎTRE, GUADELOUPE, WEST INDIES.

By Otis T. Mason.

INTRODUCTION.

The stone implements and other objects described in these pages belong almost exclusively to the celebrated collection of M. Louis Guesde, of Pointe-à-Pître, Guadeloupe. M. Guesde is the son of M. Mathieu Guesde, whose series of Carib stone implements attracted so much attention in the Paris Exposition of 1867, and Louise Loyseau, a creole, of Guadeloupe. He was born at Hamacas, Porto Rico, in 1844, but at two years of age was brought by his parents to live at Pointe-à-Pître. From 1856 to 1867 M. Guesde pursued his studies in Paris and returned to Pointe-à-Pître as register to the minister of finance, in whose office he is at present director of the third bureau. He has inherited from his father his love for collecting the relics of the ancient Caribs, and for nearly twenty years has been assiduous in his efforts. His duties calling him to reside successively in various quarters of the island, he profited by these opportunities to carry on his researches. To his zeal as collector M. Guesde fortunately adds the skill of the artist, and he has prepared two albums of aquarelles, in natural size and color, of all the types in his museum. One of these albums is in the Trocadero Museum at Paris, the other has been kindly presented to the Smithsonian Institution at Washington. So life-like are these portraits that one has no difficulty in imagining the objects before him.

In a former publication (Smithsonian Annual Report for 1876, pp. 372–393) a very large collection of somewhat similar objects, gathered by Mr. George Latimer in Porto Rico, was described and some reflections indulged in respecting those who made them. Since that paper appeared, Mr. E. F. im Thurn, of Georgetown, British Guiana, has given great attention to this subject, and is the author of several illustrated articles respecting the stone implements of the ancient Caribs. Without entering into a discussion upon this subject, and taking for granted that the Indians of the "discovery" were sufficiently advanced in culture to produce such works of art, we may better improve the present opportunity by instituting comparisons with well-known peoples.

If we would look for the evidence of the reappearance of similar forms and customs in regions wide apart, we must search out those portions of the earth that present the same general features, the same natural materials, and the same external suggestions or motives. While the similarities in art products which point to consanguinity of their makers often thrive in quite contrary circumstances, so outlandish frequently

as to seem like the distorted memory of a story, or little snatches of a melody sung in a distant land, those similarities which indicate the passing of a certain milestone of human progress are so nearly identical that the older anthropologists were wont to believe that like effects sprung from the same rather than from like causes.

Fortunately, there are two regions where the ground has not been so denuded as to prevent our knowing a great deal about the primitive inhabitants; where, also, the natural environment is so similar to that of the West Indies as to lead us to anticipate even the discoverers of their relics. These two areas are Oceanica and the Northwest coast of America from Sitka to Vancouver Island. In the first-named area we must include the Papuan, the Malay, and the Polynesian; in the second, the Thlinkit, Haida, Chimsian, Kwakiul, Nutka, and Selish stocks. We might also include the tribes of British Guiana and Venezuela, which have been so exhaustively described by Schomburgh and im Thurn.*

In all these regions we have: (1) Proximity to the sea, abounding in edible marine animals; (2) abundance of the finest timber in the world for savages to work upon; (3) lack of flint and plenty of volcanic and metamorphic rocks susceptible of the highest polish; (4) almost entire absence of clay or of some of the other natural resources for the manufacture of fire-proof vessels.

In the descriptions which follow, frequent allusions will be made to similar shapes in order to guess at the functions of M. Guesde's specimens.

The editor of this monograph sincerely regrets that he has not the specimens before him; but it was impossible to transport with safety so many valuable objects to Washington, and equally impossible for the editor to make the journey to Guadeloupe. Fortunately, M. Guesde has painted in water-colors, with scrupulous care, all of the examples figured, preserving both the color and the size. The omission of the thickness would somewhat mar the description in many cases, were we not familiar with the two typical forms of blades so frequently figured here.

A few objects not belonging to M. Guesde's cabinet will be introduced to throw light upon his figures and to supply omissions in West Indian archæology.

The classification adopted here is for convenience of comparison, and it may be that things with different function will be found side by side.

The nomenclature of the parts of stone implements is taken from John Evans' classic work, "Ancient Stone Implements of Great Britain." An ax when completed consists of haft and blade. The parts of the blade are the head or butt; the neck, or groove; the body, having sides, faces, and edge. When the hafting excavation is not encircling we may have either lateral notches or facial grooves.

*Among the Indians of Guiana, being sketches chiefly anthropologic, from the interior of British Guiana. By Everard F. im Thurn, M. A. Oxon. With 53 illustrations. London: Kegan, Paul & Co., 1883. 445, pp., 8vo.

The editor cannot conclude this introduction without paying the highest tribute of praise to M. Guesde, who has, at great cost, brought together so many wonderful specimens of ancient Carib art.

As a guide to the understanding of the true size of the specimens by the drawings, a line is placed by the side of each picture, and upon these lines true inches on the specimens are indicated by dots. This plan is resorted to because by photographic reductions exact proportions are not always observed. Whatever reduction the camera makes upon the drawing it will also make on the accompanying line, and the inch spaces will be reduced accordingly.

M. Guesde gives the following bit of personal history concerning these antiquities (pp. 53–60):

From my youth I have always been deeply impressed with what I have read about the Caribs. The sight of the stone objects which once belonged to these primitive inhabitants of the Antilles produced an indescribable impression on me.

As years went by the stronger became my desire to collect together all that the soil of Gaudeloupe might contain relating to the Caribs.

I accordingly went to work in the year 1866, and after eighteen years of constant research, never allowing myself to be discouraged by any difficulty, I have the satisfaction of being able to exhibit to ethnologists this collection, which I believe to be more complete than all others now existing, in Paris as well as in America.

My collection includes roughly-worked stones indicating an industry in its infancy; and others, on the contrary, which are brought to such a degree of perfection that it would be difficult to improve on them, either in design or workmanship.

It is necessary to state the fact which permitted John Lubbock to class the aboriginal inhabitants of the American islands among the neolithic peoples; it is because the stone is always polished. There is not a single relic formed solely by being chipped, for those rare pieces (axes or chisels) which present such an appearance also have the surface very well polished. Besides, these volcanic stones cannot be worked by chipping, like flint, quartz, or obsidian.

We come across axes so small that we ask ourselves if they were not used by pygmies, and these alongside of others so large and heavy that we dream of Titans, and no longer of men like ourselves.

In addition to all these relics, which I have gathered from the ground in all parts of the colony, both on the sea-shore and in the interior, and at altitudes of from 200 to 900 meters, enormous stones covered with strange designs are found, especially in a single quarter of Guadeloupe proper. The dimensions of these stones vary considerably. In some the drawings are so high up that it is difficult to reach them; in others they are near the ground or buried under the surface. They are scattered without order about the country and in the beds of the rivers. At St. Vincent, also, the last refuge of the Caribs, stones with inscriptions on them are found in the beds of rivers.

It is now very difficult to find wrought stones in the ground. Here and there the plow or the hoe turns up some occasional fragments. These stones lie in fact in the arable layer or stratum, and this has been so well worked that everything it contained has been brought to light. New clearings alone would favor the collector. In the deep strata would other things belonging to an earlier race be found? In the case of Grande-Terre it would be impossible, for as soon as we have passed the vegetable mold we reach calcareous rocks, Madreporic formations containing numerous fossil shells and dog-fish, which preclude all idea of the presence of man. It appears to me more probable in the case of Guadeloupe, which is of more ancient formation, and which must at all times have offered more resources to man.

However large may be the number and variety of the types which I possess, I still consider my work incomplete.

It constitutes only the prolegomena of what I would wish to accomplish.

In the presence of this collection, one is led to ask if these wrought stones are the work of the *Yguiris* or of the Caribs, or if they would not belong to these two races. We are in almost complete darkness on this point. It is necessary to throw some light on the subject. This could be done only by visiting all the Lesser Antilles, which were already occupied by the Caribs on the arrival of Columbus; the Greater Antilles, from Porto Rico to Cuba; and Trinidad, which is but a fragment recently detached from the continent; by gathering carefully in each island all the wrought stones which would certainly be found there; by studying with the utmost care the inscribed stones; by classifying separately the inscriptions and relics according to locality, and finally by comparing the whole together in order to determine the points of relationship.

Having completed this first labor in the Greater and Lesser Antilles, it would be necessary to collect together the relics from the soil of Guiana, and, taking them as types, to compare them with those of each Antille separately. Then only could we come to some conclusion. We would have laid open to us, in fact, the now silent history of these aboriginal inhabitants.

I have been able to obtain some pieces from Porto Rico, as follows: 1st. Celts of all sizes, in general well polished, but some with a fine brilliant glazing. 2d. A mortar representing a bat—a very curious piece which must have required long months of labor. 3d. An idol representing a man lying on his belly, and supporting a mountain on his back. A very remarkable peculiarity is that the legs are bent as if in the act of swimming. I think that this idol is the personification of some marine deity, protector of an island. 4th. An enormous necklace, covered with inscriptions on one of its lower surfaces. This necklace was evidently slung over the shoulder like a hunting-horn. 5th. The lower part of another necklace, but without any inscription. 6th. A small netting-needle. 7th. Some remains of pottery (heads of

men and monkeys modeled with great boldness, evidently forming cup-handles) and the upper rim of a cup which must have been of great diameter. Some of these fragments of pottery still bear traces of a fine red glazing.

I must acknowledge that during two sojourns at Porto Rico—one of six and the other of two months—I never came across an ax. Moreover there is not a single ax in the superb collection presented to the museum at Washington by Mr. G. Latimer, and which is entirely from Porto Rico. The abundance of axes in the Lesser Antilles and their complete absence in Porto Rico would seem to indicate a difference of race in the inhabitants of these different islands.

I have been able to obtain five perfect celts and four fragments from Martinique, one single celt—but very remarkable for form and polish—from Dominica, two celts and three axes from St. Lucia, and one celt from Santo Domingo (the Hispaniola of Columbus).

No typical difference can be established between the celts, whether they come from Porto Rico or from Martinique, Guadeloupe, Dominica, and St. Lucia.

Now, since the strata of the Lesser Antilles do not contain the material used in some of these celts, it is certain that they were not made where they were found. Should we not, therefore, infer from this that they all have the same origin, that they all come from the continent or from the Greater Antilles?

I have in my possession a club (*baton*) from the Galibis of Dutch Guiana. This club has a certain age. The wood, of a red color when freshly cut, has assumed a very deep black hue; the cotton thread around the handle is very dirty. The weapon has seen service. This club is exactly like those used by the Caribs of the islands, and which Father Dutertre has described, but the peculiar part of it, the thing that gives it an enormous interest, is the green celt fixed in its lower extremity. Now, this celt resembles all those which I have found in Guadeloupe and the other islands. Is it of modern manufacture? Is it not rather the work of the first inhabitants of the continent? Has it not been found in the soil and used by its discoverer? I would decide without hesitation in favor of the latter hypothesis, for it is covered with a patina which only a long continuance in the soil could give it.

Here is another fact which seems to prove that the Caribs of Columbus and of Father Dutertre are the same as those of Guiana.

The exterior distinguishing color is not always that of the stone of which they are made. The color, which is black, red, yellow, brown, or bluish, partakes essentially of that of the soil from which they were taken. Those from Grande-Terre, whose calcareous soil is covered with a thin layer of black and compact vegetable earth, all have the colors more or less dark—brown, red, black—while those from Guadeloupe proper, whose soil is covered with a thick layer of more or less ferruginous red earth, have the tints lighter. Yellow specimens are numerous there. Many of them have preserved their normal tint. These

are the ones found near rivers. Continually washed by their waters, they have not acquired the coating of rust with which those buried in the ground are covered.

So true is the above that every fresh break shows the interior of the stone to be of a different color from the exterior.

All these rocks are volcanic, and are naturally either black, blue, or green.

This peculiarity does not generally exist in polished celts. The glazing has unalterably fixed the color of the stone. They have, in consequence, remained free from all oxidation, and appear as if just from the hands of the workman.

Axes.—Axes are more numerous than all the other pieces. That may be easily understood, the ax being of prime utility to man. Some are long and narrow, others short and wide. Some are very flat, others very thick. Some are very small, while others are of enormous size and weight. I have two weighing, respectively, 4 kilograms, 750 grams, and 4 kilograms, 775 grams. Some are of very simple construction, merely the natural stone of appropriate form, which a little working transformed into an instrument; while others, on the contrary, are true masterpieces, which will bear comparison with those found in Denmark only. The latter are very rare. They were evidently used for purposes of parade, for it cannot be allowed that the author of such a work would have exposed it to be broken at the first shock, thus losing the product of the labor of several months, I might even say of several years.

The ax admits of four distinct parts—the head, the neck, the blade, the cutting edge.

The head is sometimes round, sometimes flat, sometimes very small, sometimes as large as the blade. Some axes have one or several transverse grooves, some have none at all, others a single longitudinal groove. The last are very rare. Pierced axes are very rare. The holes served, if they offer any assistance, to fasten the stone to the handle; if not, to suspend ornaments. The head played an important part in attaching the ax to the handle, for there can be no doubt that all these axes had handles. The small as well as the large ones were fixed on a wooden handle by means of cords made of cotton or mohot.

The neck is more or less lengthened. Sometimes it is formed by lateral notches only, but generally by a circular depression.

The blade varies considerably in form, length, and thickness. There is no proportion between it and the other two parts.

The edge is more or less distinct. In some axes it is so perfect that one would think they had been sharpened the day before.

I have three double-edged axes—two of moderate size, the other very small. I have four axes of which the head is prolonged into a long tail, and which resemble (one of them especially) that which has been termed Montezuma's ax. I have also a certain number, both small and very large, with a slight but decided protuberance on the lower part of

one side of the cutting edge, which suggests the idea of a tool appropriated to some special purpose. Finally, I have some axes with the blade curved like that of a cimeter. These are rare.

Celts.—Celts vary much in form, size, and color. Some are slender with a sharp point, others are massive with a blunt point; some are broad and flat, others narrow and deep; some reach enormous proportions, while others are very much reduced in size.

Celts are scarcer than axes in Guadeloupe. Most of them are made of a handsomer, harder material than that used for axes, such as serpentine, jade, or jadite. The fine glazing of the stone, also, is found only in celts. I have some, large and small, made of the volcanic stone used ordinarily for axes. These are very well polished, but not glazed. This handsome glazing gives an exalted idea of the industry of these savages, for it could not be done better in our days.

The Caribs made use of the living forces of nature to fix the celts on the wood. But to introduce a celt into a young tree and let the tree grow till the resistance was sufficient, required many years. I believe, therefore, that they rarely had recourse to this process. They evidently followed the same method employed by the Canaques and other savages of the present century ignorant of the use of metals, whose celts do not differ from those found in our islands. This method consisted in fixing the stone by the aid of very fine cords in a socket prepared in the wooden handle.

I must not forget to mention the shell celts. These are not made of living shell, which would not have been hard enough for the purpose, but of fossil shell. They are very rare. They were extracted from the outer edge of the *Strombus gigas*, very common in the Caribbean Sea.

It is to be supposed that the glazed celts were rather warlike weapons than instruments of labor, for they offer more resistance in proportion to their size, and we know besides that the savages used in war whatever had most value in their eyes. The very large-sized celts must have served as wedges in splitting trunks of trees.

Casse-têtes.—The casse-tête type is furnished by a stone, either round or with bilateral facets, in the center of which is a more or less deep groove for the wooden handle. One can easily conceive the power of such a weapon wielded by a muscular arm in hand-to-hand combat.

Some are more perfect in form than others. Every one was free to fashion so important a weapon as best suited him.

But what astonishes the observer is the small size of one of these relics. Evidently it could have been only an amulet, worn with the idea of preserving its owner from the blows of the weapon it represented.

Other casse-têtes were used without handles. Only two types figure in my collection. This weapon had not the value of the preceding.

Pestles, grinders.—Pestles and grinders are of various forms and sizes. My collection includes a certain number of them. I possess a single specimen, which was used with both hands.

Mortars.—Mortars are not very numerous. This is explained by the fact that any hard stone which was flat and smooth would take their place. The complete mortar could have been only an article of luxury belonging to a cacique.

Shall I designate as mortar that rounded concave stone with regular grooves descending from the central point to the rim? Although quite hollow on its lower surface, I do not think it could have been anything but the lid of a large vase, grooved or fluted in like manner. In fact this mortar would have had no fixed position. It could not remain stationary in the position necessary to make use of it. Or should we not rather think that the maker of this piece wished to represent a miliform cactus so common in the Antilles? And in this case should we not rather class it among the idols? (Fig. 172.)

Dishes.—There are but two dishes in my collection: 1st. A large one of rude workmanship. The concavity only is polished; the exterior rough and very irregular. 2d. A small one of very remarkable finish. It is in fact very well polished on all its inner and outer surfaces.

Harpoon.—One single harpoon, slightly broken at the three extremities. The absent parts can, however, easily be restored in following the lines traced on the body of the piece. This instrument is very remarkable.

Hooks.—I have two hooks very different in form. Both are a little broken, but easy to reconstruct by following the method indicated above.

Awls.—Awls are rare. My collection includes only two of them, but I must state that the material employed is harder than that of the ordinary tools and instruments.

Chisels.—Chisels are numerous and of various forms and sizes. The basil of the cutting-edge is perfect. Some of them are made of the same material used in the fine celts, and, like the latter, have the handsome glazing mentioned above.

Vases.—I have only two vases. One is of guaiacum. The handle is perfectly isolated from the body of the vase. This piece is of very great interest. As the guaiacum is incorruptible, we need not be surprised that it has come down to us. It was found at Bertram Creek, the last quarter of Guadeloupe inhabited by the Caribs. Its edges are worn and hacked, and bear evidence of having been a long time in the earth. I have seen a small tortoise of the same wood found in a cave at St. Vincent.

The other in my possession is of stone. It is an astonishing piece from its general regularity and its contour.

Shall I class among the vases that small cup with a rather long spout? It rather resembles a spoon, and I think that it might be designated as such, taking into consideration the break, which leads us to suppose that a prolongation forming a handle formerly existed.

Netting-needles.—There is one small netting-needle, very well made and very regular, which evidently served to net cotton, and two other larger, more massive ones, which served to prepare cords.

Idols.—The idols are six in number.

1st. One representing a man extended on his back, the legs bent under him, the arms applied to the chest, the head covered with a cap, the sexual organs very conspicuous. It is well finished and must have cost years of diligent labor. (Fig. 200).

2d. One representing a man on one face and a monkey on the other, is very interesting (Fig. 210). It was found at Matouba. The work on this statuette is rude. The hand that made it was wanting in skill. But what shall we say of the genius which inspired this combination of man and monkey? Should we not consider Darwin only a plagiarist?

3d. Another found in Guadeloupe, of the same type as that from Porto Rico, but much larger and so rough that it cannot be determined what it represents. The under surface is slightly concave.

4th. A small granite pyramid, with three grooves or furrows on its lower part. It was found on the island of Désirade.

5th. A head with two faces surmounted by a Phrygian cap. This head was to be fixed on another stone or a piece of wood forming the body of the idol, for it is much too heavy to admit of the supposition that it was carried in the hand. I have vainly searched for this complemental lower portion at the place where I found the head.

With this last idol we must place an ax and one other piece, both having lines identical with those of the idol head. I think they represent faces.

Amulets.—The principal amulet is of carbonate of lime in bladed crystallization. It represents a *maboya* (evil spirit) with bended arms and legs, and the virile organ in a state of action. The shoulders are pierced posteriorly to allow of the suspension of the amulet. The other amulets are medallions of different sizes, more or less round, all pierced with a small hole to admit of suspension. I have a single small crescent of stone, an evident representation of the caracoli of metal. This crescent must have been set in wood, unless it was provided with a cotton string terminating at each extremity in a small cord for suspension.

Disks or quoits.—I have six disks, large and small. One especially is a very remarkable piece of work. There is no doubt about the determination of these relics. The Caribs played quoits.

Edicule.—A small monument having handles on each side, on top of the handles a platform disappearing under a vault. There is a hole in the middle, presumably the place for an idol. This relic is very curious, and reminds one of the Mexican teocalli. (Fig. 194).

Chisels of shell.—Besides the various stone tools, my collection includes a series of very fine chisels extracted from the outer edge of the

Strombus gigas. This part of the shell is very thick and harder than stone. It is certain that the Caribs did not use the living *Strombus*, but were careful to take the fossil *Strombi*, which had in time acquired the hardness of ivory.

Stone for making axes.—I have in my possession a very interesting stone, which has inscribed on it the use for which it was intended. It has concavities on three of its surfaces. It is evidently a kind of grind-stone, on which stones were rubbed in order to shape them.

Since writing the above, I have had the good fortune to discover in Grande-terre, in a piece of ground which had not been plowed for 60 or 80 years, two tools of flaked flint—a knife and hacking-knife. This discovery somewhat modifies the theory held to this day by writers on America that *flaked flint* does not exist in the Antilles.

It is very evident however that these two flints were not dug from the soil of the island and then flaked by their possessor, for this stone does not exist in Grande-terre or Guadeloupe in a state of nature.

These two *flaked flints* establish, in an irrefutable manner, the fact of a migration of men from the valleys of the Orinoco towards the islands.

I. UNPOLISHED IMPLEMENTS.

These do not form a class apart, but they are exceedingly useful as showing the method of blocking out the more elaborate implements, when nature has not supplied a polished pebble sufficiently near to the desired pattern. The three methods of chipping, picking, and grinding are all outlined in this group (Figs. 1–8).

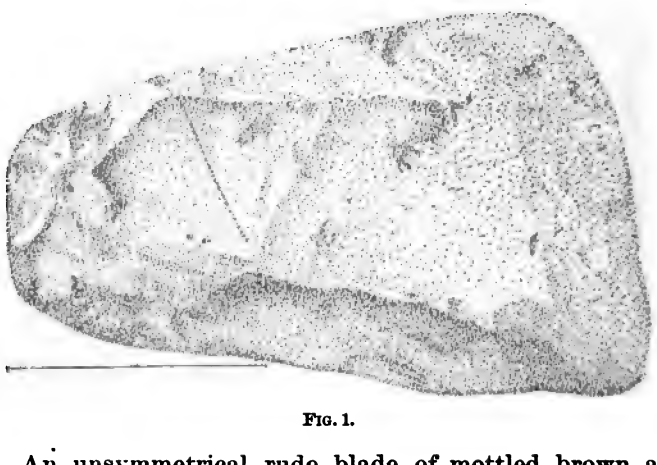


FIG. 1.

Fig. 1. An unsymmetrical, rude blade, of mottled brown and gray color. The surfaces are nearly as they were left by the removal of great spalls; but the edge is ground, and has that peculiar slope belonging to old axes battered on the corner away from the workman. There is as yet no indication of groove or haft notches, and, therefore, if the

specimen was used with a handle, the blade must have been inserted or lashed (see Fig. 14).

Length, $4\frac{8}{10}$ inches; greatest width, 3 inches.

Fig. 2. A rudely-chipped blade of black color. The outline is bell-shaped, and with sufficient grinding and polishing would resemble some of the more beautiful objects in the collection (see Fig. 65 and others).

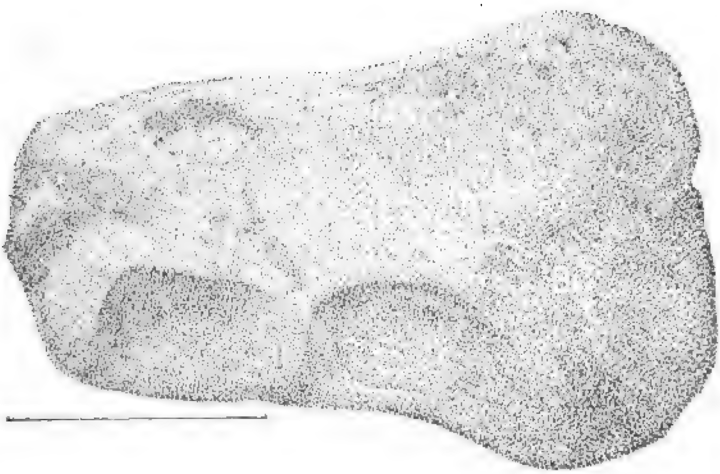


FIG. 2.

The implement has already a pleasing outline, and the form re-appears in Costa Rica and Chiriqui, where great numbers of celts of this shape, but smaller, were recovered.

Length, $5\frac{4}{10}$ inches; width, $3\frac{5}{10}$ inches.

FIG. 3.

Fig. 3. A chipped blade of very light brown surface, subtriangular in outline. Much of the surface is untouched, and there is just enough of lateral notching, &c., to show that the great variety of form in such implements after they are finished is partly due to nature and partly to the workman's desire to produce a certain kind of implement. It is

very much like our handwriting; we try to imitate certain copies, but we only preserve the type while we stamp our own individualities upon them. All sorts of pebbles lie at the hand of the savage mechanic, none of them just what he wants. He selects the best and founds a new type for the learned archæologists. A collection of pebbles from the West Indies would be very instructive in showing just how far nature had been the draughtsman and the teacher of the aboriginal artisan. This implement, though rude, shows much use, and rather hints that fine polish is evidence of age and much use in many cases.

Length, $5\frac{4}{10}$ inches; greatest width, $3\frac{5}{10}$ inches.

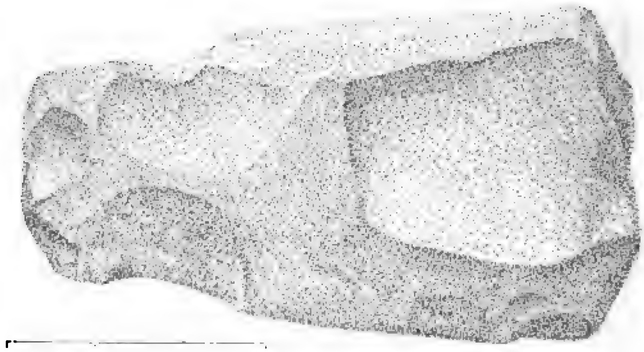


FIG. 4.

Fig. 4. A coarsely-chipped blade of purplish-brown surface. The spalls have been taken off with great boldness from the faces and the groove. The specimen is so broken at the edge as to make it uncertain whether it has been used at all.

Length, $7\frac{3}{10}$ inches; width, 4 inches.

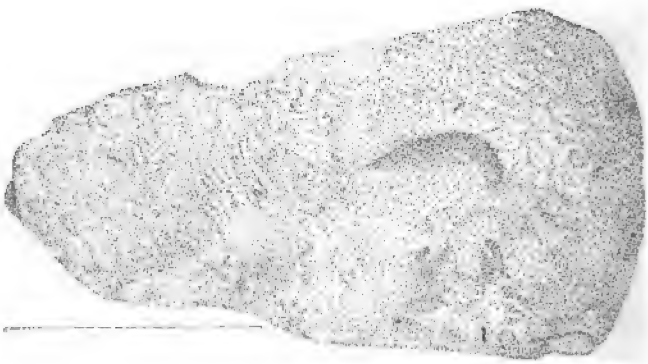


FIG. 5.

Fig. 5. A chipped blade of beautiful orange-brown surface, which has been much modified by grinding. In type it belongs to a low order of axes, having only lateral notches. On the faces are very slight haft

cavities, showing plainly the pecking. Flint implements with smooth edges and partially ground sides are quite numerous in European collections, leading to the conviction that polished celts are of two kinds, those polished at once and those polished by years of grinding.

Length, $7\frac{1}{2}$ inches; width, $4\frac{1}{10}$ inches.

FIG. 6.

Fig. 6. A chipped blade of slate-brown color. The shape is that of the typical hoe, the sides being rather incurved than decidedly notched. The surfaces are much worn and the edge ground away unevenly, furnishing another example similar to those of England and the Continent, above noticed, made of flint. It is in many cases difficult to decide how much the change of surface is due to use and how much is due to weathering.

Length, $7\frac{3}{10}$ inches; width, $4\frac{3}{10}$ inches.

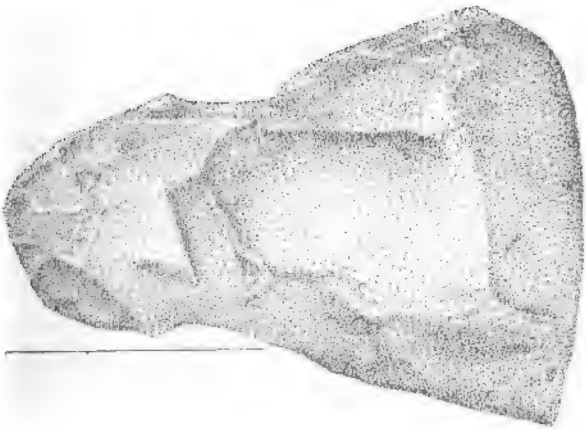


FIG. 7.

Fig. 7. A chipped blade of light-brown color. The form decidedly resembles that of the chipped hoe occurring in many parts of the United

States. By this it is not meant that the maker of the implement was an agriculturist. There are slight indentations at the sides for hafting, and the edge is slightly worn off on what we may be allowed to call the outside.

Length, $6\frac{8}{10}$ inches; width, $4\frac{8}{10}$ inches.

Fig. 8. A chipped blade of brown color on the weathered portions. There can be no question, from the general outline of this rude specimen that we have here blocked out, what was designed to be a finished

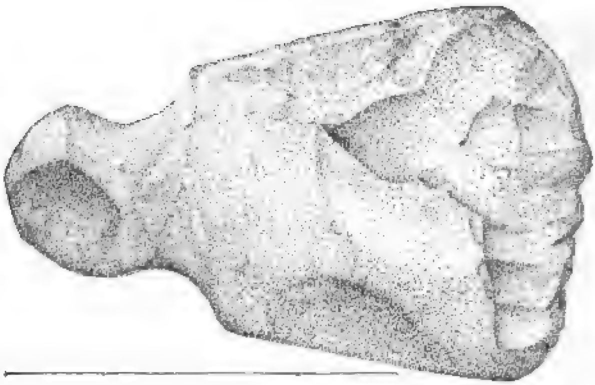


FIG. 8.

blade with small butt (Figs. 193, 194). The edge chippings exhibiting the natural black color of the stone, seem to be much more recent than the rest, and may have resulted from accidental breakage.

Length, 6 inches; greatest width, $3\frac{8}{10}$.

II. POLISHED BLADES WITHOUT HAFT-GROOVES.

The typical "celt" of the West Indies is the almond-shaped variety, called "petaloid" by Mr. im Thurn, so distinctly recognizable that John Evans receives an alleged Scottish specimen of the same shape with suspicion. But this petaloid or almond variety runs into other forms, notably what we might call the Papuan type. The petaloid type was doubtless inserted or "perserted"; but the flatter Papuan form was always inserted, and served with sennit or other twine. The hafts also were of different shapes; that of the former was straight, that of the latter lambdoidal. In certain portions of the Antilles the greatest abundance of shell chisels are found, and it would not be marvelous to discover in stone implements a close resemblance to some of these.

When we remember that we are speaking of a maritime people who had the greatest abundance of ship timber at hand and leisure to work it, and that they had the very best volcanic rocks to convert into implements, we have only to turn either to New Guinea or Queen Charlotte

Islands to reconstruct in part the lost social fabric of those who used M. Guesde's stone adze blades.

The Caribs had two kinds of boats—a very large canonia and a small couliala, both dug out of a single trunk. The former attained a length of 40 feet and were 7 or 8 feet wide. They could carry fifty persons with arms and baggage, and were worked with oars and sails. The coulialas were not more than 20 feet long and 3 or 4 wide; they were propelled with paddles. The Indians of the Northwest Coast have the same distinction of dug-outs. In the National Museum at Washington may be seen both the immense family boat, over 60 feet long, and the smaller, more shapely whaleboat, about 12 feet long, from the same people, carved from the *Thuja gigantea*.

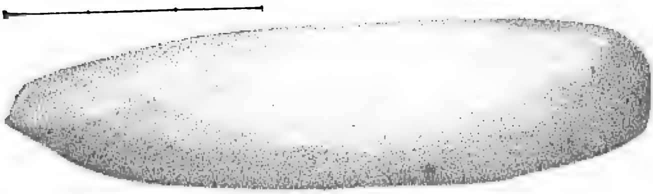


FIG. 9.

Fig. 9. A celt or blade of the simplest form, and dark brown in color. In this specimen we have an example of economy in working. Just as the ancient flint-workers of France began their celts by grind-

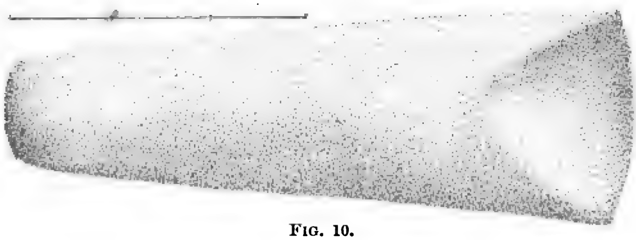


FIG. 10.

FIG. 11.

ing down the edge of a chipped core; so the ancient West Indian levied upon Nature for all the work he could extort from her, and was more fortunate than his brethren of France, for Nature did his polishing for

him. There would seem to be two edges to this specimen, but the smaller one is a little modified from the natural shape.

Length, $7\frac{1}{2}$ inches; width, 2 inches.

Figs. 10 and 11. Two blades or celts of brown surface and highly polished. These objects should certainly be called chisels if any are to receive that name. Figure 10 has sloping sides, while in Fig. 11 they are almost parallel. The outline of each is perfectly symmetrical and the edges so neatly bevelled as almost to create a suspicion of their savage origin. These specimens would be considered unique in any area of lithic culture, and certainly the West Indies have produced no others similar. (See *Timehri* I, p. 265, 1–7.)

Length of 10, $6\frac{6}{10}$ inches; of 11, $5\frac{4}{10}$ inches.

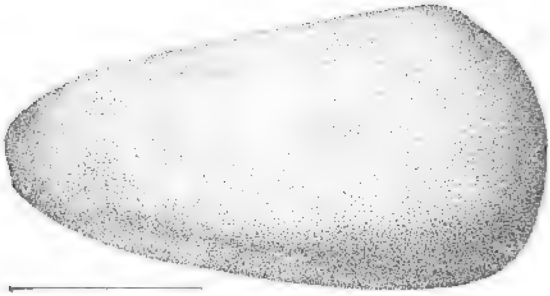


FIG. 12.

Fig. 12. Polished blade from New Caledonia. The material is of a clear green color resembling jade. Professor Baird has given the name jadoid to this whole class of minerals so well known to archæologists. This shape is well known throughout the Papuan area, most of the blades being mounted in curiously-wrought lambdoidal handles, very thin and wide above and at the blade. The wonder is how such tools could have been used with any effect (see Fig. 14).

Length, $5\frac{7}{10}$ inches; width, 3 inches.

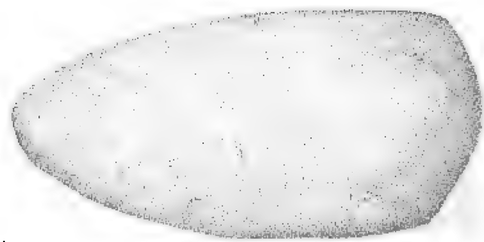


FIG. 13.

Fig. 13. Polished blade from New Caledonia, of light-mottled green color. It resembles Fig. 12 in general appearance, but the edge has been much used, indicated clearly by the battering on the outer side.

Length, $7\frac{6}{10}$ inches; width, $3\frac{8}{10}$ inches.

Fig. 14. Hafted blade from New Guinea, of dark-green colored material, probably serpentine. The lambdoidal haft and the serving are

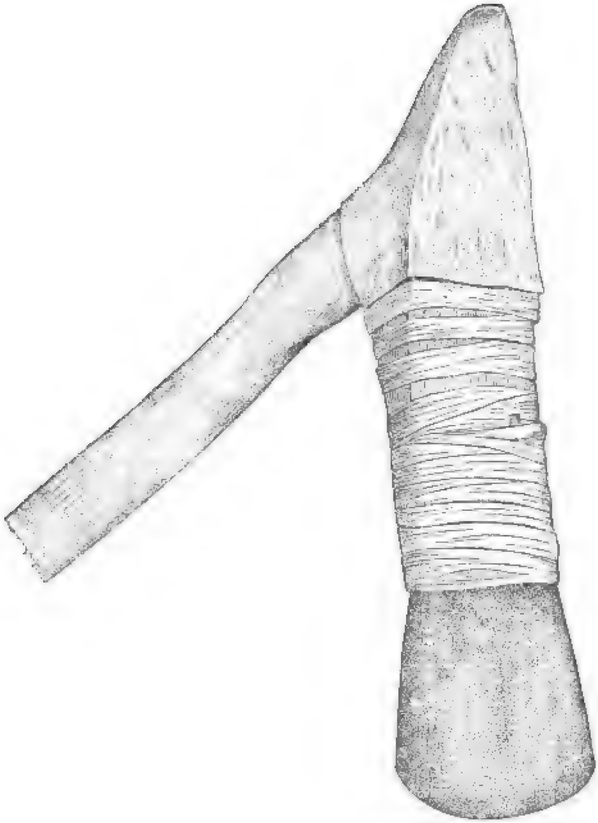


FIG. 14.

shown, but M. Guesde's figure conveys too much the idea of an adze. The plane of the blade splits the haft, is not perpendicular to the plane of the haft.

Length of shank and blade, 12½ inches; width of blade, 3 inches.

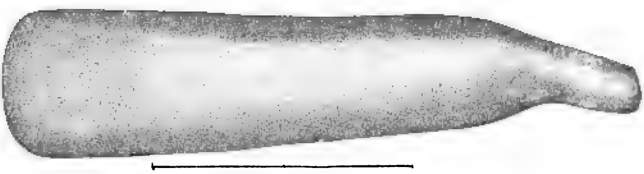


FIG 15.

Fig. 15. A beautifully polished blade of hard, black-colored material. This specimen is remarkable for its curved butt, straight sides, flattened

faces, and fine edge. The elongated hexagon in section is not uncommon in the West Indies, and occurs very frequently in Costa Rica. The bent butt of the blade is a very common feature in shell blades. Perhaps the only truth about the shape is that the savage found it so and let it stay.

Length, $4\frac{9}{10}$ inches; greatest width, $1\frac{1}{10}$ inches.

III. FACES CONTINUOUS, SIDES INCURVED OR NOTCHED.

The next type which is to be considered is that in which the faces are continuous from the edge to the opposite extremity, but the sides, near the butt, have been modified in various ways, apparently to aid in hafting. The butt, or head, also passes through a variety of modifications, almost as numerous as the proximal end of leaves. Such implements or forms have a certain number of possibilities. They may have been felling axes, hoes, adzes, battle-axes, ceremonial axes, or simply works of art. That is to say, similar objects have been found performing these functions in different parts of the world. Reverting to our typical areas we are at a loss to proceed. The Haida do not use implements of these shapes; the Mound Builders did, however, and many of this class can be duplicated in our collections.

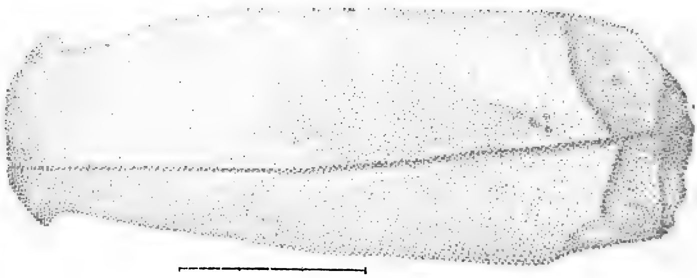


FIG. 16.

Fig. 16. A long, slender blade, of blackish-brown color. The butt is irregularly curved, and rimmed or hollowed at the notches. The hafting space is hardly to be called a notch, passing imperceptibly into the sides below. The latter are not alike and the edge has been recently broken. A natural seam mars the surface from top to bottom.

Length, $11\frac{1}{2}$ inches; greatest width, $4\frac{3}{10}$ inches.

Fig. 17. A rude blade, of very dark-colored material that has weathered to a creamy yellow on the exposed surfaces. The butt is rough and truncated. The hafting spaces have different curves and widens sharply to the sides of the specimen; the latter pass insensibly into the edge. In Mr. E. F. im Thurn's Timehri Plate VIII, Fig. 6, is a similar lingulate form, where the sides continue to the truncated butt, and the

little notches for hafting are only about one-fourth of an inch wide and deep, and are squarely cut in.

Length, 7 inches; greatest width, $4\frac{4}{10}$ inches; notch, 3 inches wide.

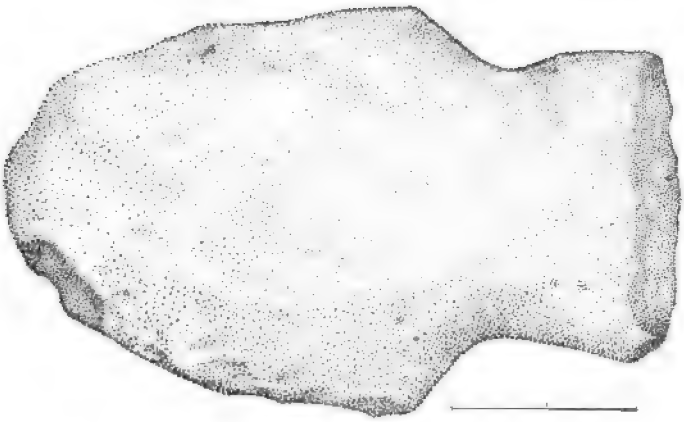


FIG. 17.

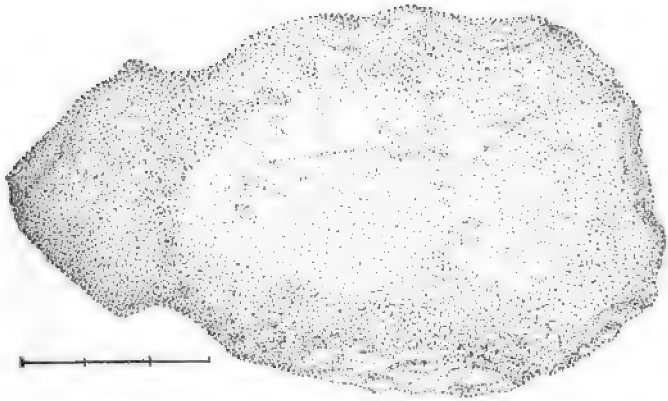


FIG. 18.

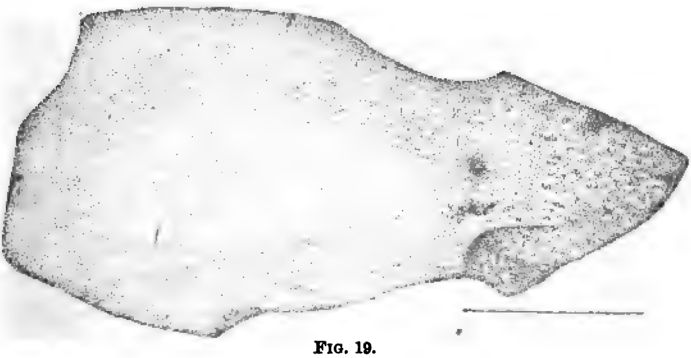


FIG. 19.

Fig. 18. A rude, massive blade of bright brown color. The butt is triangular in outline. The attachment of the handle was secured by

concavities at the sides and a very slight pecking on the faces. The edge is much broken, and large fractures on the sides, as well as the weathering, give to the implement the appearance of great age. This form is very common throughout the United States, especially in those areas where the aborigines were agriculturists.

Length, 10¾ inches; width, 6½ inches.

Fig. 19. A massive blade of orange-brown patina. In general appearance the specimen resembles Fig. 18, but the polish is finer and the butt more acute, the unlikeness of the two lateral hafting spaces being very notable. The edge has been broken and ground again.

Length, 11¼ inches; greatest width, 5½ inches; the edge could not have been more than 4 inches.

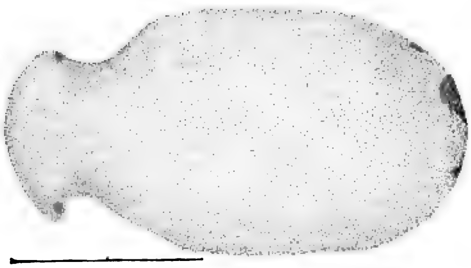


FIG. 20.

Fig. 20. An elongated ellipsoidal blade of light-brown color. The butt is gracefully rounded and rimmed or bent down over the notches like the rim of a pot. The latter notches pass insensibly into the unsymmetrical sides.

Length, 5 inches; width, 2$\frac{6}{10}$ inches.

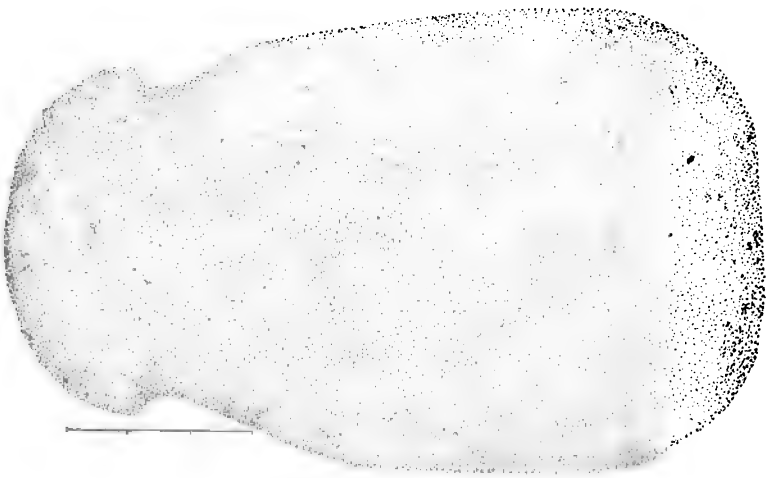


FIG. 21.

Fig. 21. An enormous blade of *café au lait* color, not only the largest in M. Guesde's collection, but no other has been reported from this area that approaches it in size. The attractiveness of the specimen is equal to its size. The butt, concavities, sides, and edge form one unbroken curve. A slight bulging on the lower side and the worn appearance

of the edge on the same side lead to the suspicion that blades of this type were made with inner and outer sides.

Length, 12¼ inches; greatest width, 7¾ inches.

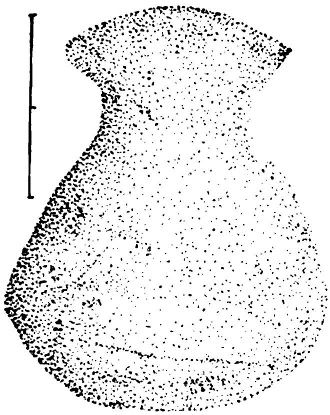


FIG. 22.

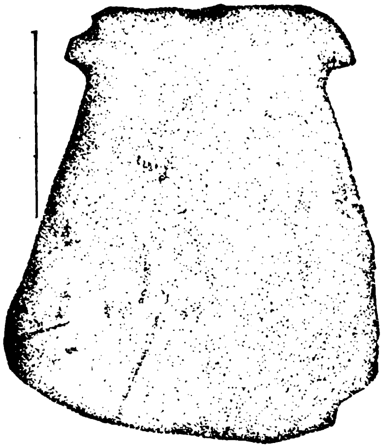


FIG. 23.

Fig. 22. A mēri shaped blade of slate-brown color. The interesting feature about the specimen is that the sides and butt are squared even more than is shown by the drawing.

Length, 4$\frac{4}{10}$ inches; width of blade, 3½ inches.

Fig. 23. A thin, flat blade of mottled-blue and cream-colored marble. In type it is similar to several in Sir Thomas Graham Briggs' collection from St. Vincent and Antigua (*Timehri*, II, 263; III, 111). M. Guesde says that identical forms have been found in Dutch Guiana. Mr. im Thurn believes this form to have been used like a hoe or adze rather than as an ax. The side notches relegate the specimen to the hoe class. Especial attention is here called to the slight offset on the left of the butt and the beaked form of the right. Both of these features will

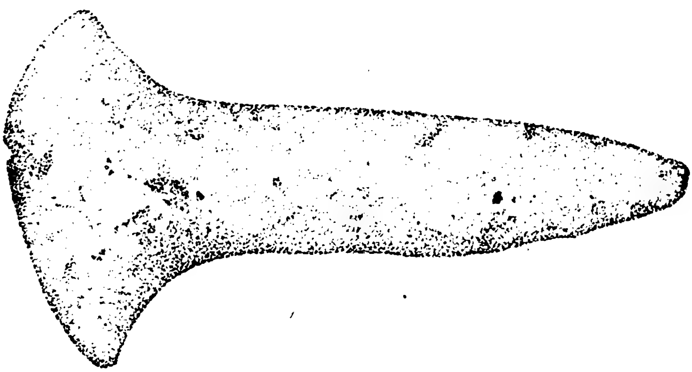


FIG. 24.

appear again in many forms much more elaborated. This specimen was found in St. Anne.

Length, 7$\frac{3}{10}$ inches; greatest width, 6$\frac{2}{10}$ inches.

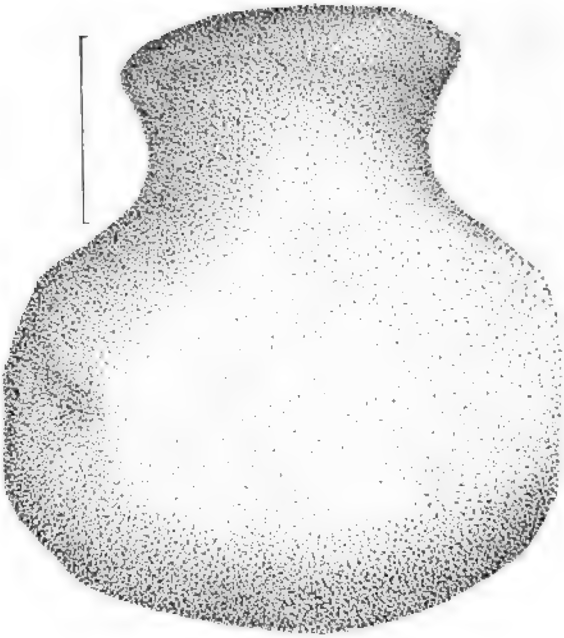


FIG. 25.

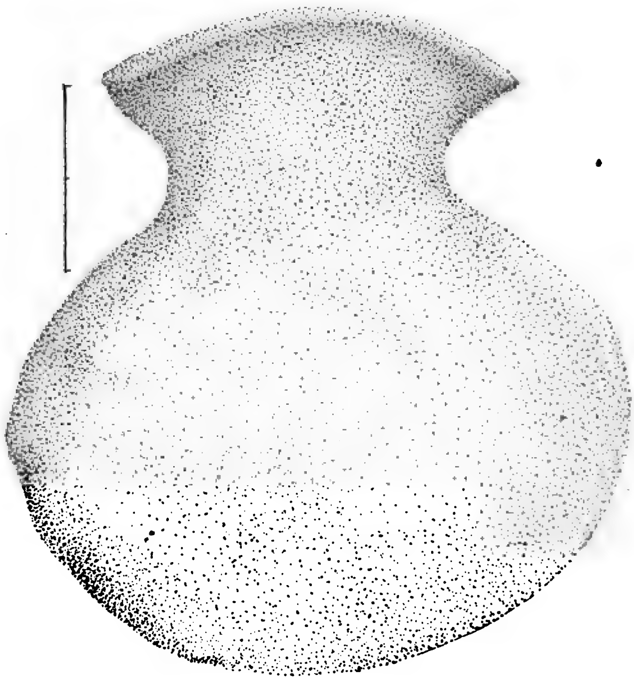


FIG. 26.

Fig. 24. A bell-shaped blade of brown patina and elongated body. It is difficult to conjecture how such a blade could be fastened in a haft. There are found in the Antilles frequently implements for smoothing, shaped like this specimen inverted. This form with the edge at the small end is unique.

Length, $5\frac{4}{10}$ inches; width of blade, $2\frac{8}{10}$ inches.

Fig. 25. A very plain blade, of light-brown color. It is rude and irregular in outline, and shows considerable age. This type, however, is well preserved, one continuous line bounding the specimen from one extremity of the butt to the other.

Length, $5\frac{3}{10}$ inches; width, $4\frac{6}{10}$ inches.

Fig. 26. A blade of very light color, but of better finish than the preceding. The butt is well curved, and the rest of the outline forms a continuous curve. It is very interesting to observe the multitude of forms in which a continuous curve bounds the implement below the butt.

Length, $5\frac{1}{2}$ inches; width, $5\frac{1}{10}$ inches.

FIG. 27.

Fig. 27. A square-edged blade of very dark patina. If one were allowed to use the term ax for West Indian stone implements, this example should be called a broad-ax. The characteristic features are the convex butt, the deep antero-posterior notches, the very slight swelling over the notch on the faces, not always shown in the drawing, the dissimilar sides—the one convex, the other straight—and the squared and beveled edge. The difference of sides again points to the conclusion that these savages had begun to have a front and rear to their axes.

Length, $5\frac{9}{10}$ inches; width, $4\frac{7}{10}$ inches.

Fig. 28. A large, broad blade, of blackish-brown color, and in contour resembling a wide-mouthed jar. At the butt the upper line is a long curve and the beaks quite slender. The lateral notches are tolerably

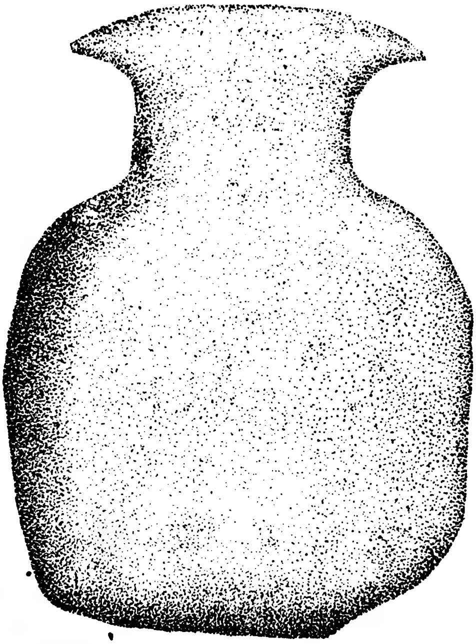


FIG. 28.

FIG. 29.

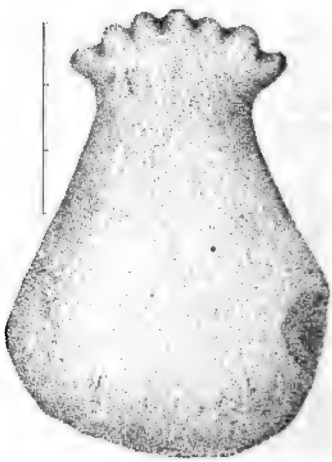


FIG. 30.

symmetrical, their lines passing gracefully into the sides. The edge is squared, but broken on the right corner and reground.

Length, $8\frac{8}{10}$ inches; width of body, $6\frac{4}{10}$ inches; of neck, 3 inches; of butt, 5 inches.

Fig. 29. A pear-shaped blade of very dark material and exquisite polish. Especial attention is called to the longitudinal groove at the butt, the length of the beaks, the unequal notches, the asymmetry of the sides, and the obliquity of the edge. From Marie-Golante.

Length, $8\frac{1}{2}$ inches; greatest width, $5\frac{3}{10}$ inches; width of neck, $2\frac{8}{10}$ inches.

Fig. 30. A broadly-spatulate blade, nearly black. It is tolerably symmetrical until the sides merge into the edge. On the upper margin are seven scallops, the same feature occurring in another type. M. Guesde thinks the scallops were useful in lashing.

Length, $7\frac{2}{10}$ inches; greatest width, $5\frac{3}{10}$ inches.

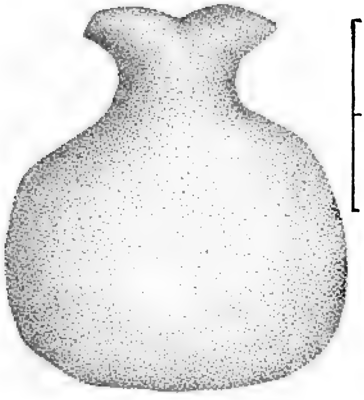


FIG. 31.

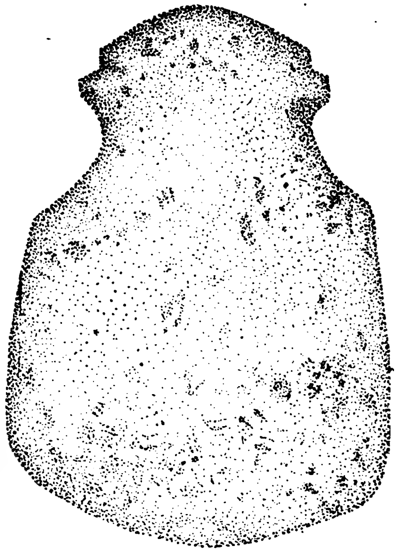


FIG. 32.

Fig. 31. A hoe-shaped blade, of the double-beaked variety and light, marble color. The beaks are reduced to the simplest form and divided by an emarginate curve. The lateral notches are not separated from the other parts, their lines being continuous from beak to beak. The highly polished and finished condition of this specimen separate it from the agricultural class, although its shape is that of the plantation hoe. A similar, but clumsier, butt is seen in im Thurn's volume (Timehri III, Plate vii, Fig. 2). His blade, also, is nearly rectangular.

Width, $3\frac{6}{10}$ inches; width of neck, $1\frac{3}{10}$ inches.

Fig. 32. A massive blade of mottled yellow and brown color. The butt is very gracefully rounded and rendered beak-like by a notch or chamfer on each side. This feature of the beak and crest should be especially noticed, because it will have a higher evolution further on. The original curves of the hafting-space are unequal and terminate abruptly at the

sides, which are tolerably straight. They are also of unequal length, and the edge has the customary appearance of one sidedness.

Length, $8\frac{7}{10}$ inches; greatest width, $6\frac{3}{10}$ inches; shank, $3\frac{4}{10}$ inches.

FIG. 33.

FIG. 34.

Fig. 33. A massive blade of yellowish-brown color, belonging to the two-beaked variety. The butt is narrow and deeply scalloped; possibly it was formerly mucronate at the apex and had a double countersunk perforation. The beaks are mere bosses or projections. The concavities of the haft-space are very unequal, preparing us for the type further on characterized as the bill-hook (Figs. 77–83). The edge is correspond ingly modified.

Length $10\frac{2}{10}$ inches; width $5\frac{1}{2}$ inches.

Fig. 34. A finely-polished, massive blade of dark, slate-brown color. It is of the two-beaked type, but severely plain and symmetrical. The butt is squarely truncated, and the beaks are without flutings of any kind. There is a double countersunk perforation midway between the beaks. No depressions are made for hafting, the lower part being shaped like a tunic. Mr. im Thurn (Timehri, I, 263, Fig. 1), an intermediate form between this and the next example. The crests are made distinct by a median square notch, and there is just the least attempt to produce the long, trapezoidal neck of our next figure. The most remarkable feature about im Thurn's specimen is the engraving on the face of a lozenge, having lunate figures above and on either side. Sim-

ilar implements are reported to be in the Blackmore Museum, one from Guiana.

Length, $10\frac{4}{10}$ inches; width, $5\frac{3}{10}$ inches.

FIG. 35.

FIG. 36.

Fig. 35. A very symmetrical blade, of purplish-black patina. The butt, though very plain, belongs to the double-beaked variety, and has a long, shallow chamfer on the top. A slight swelling on the sides of the butt relegates this specimen to the rimmed class. It is retained here, however, as a connecting link to more elaborate forms. The hafting space or neck is long, tapering, and shouldered at the sides. The sides also taper outward and the edge is unsymmetrical. The surface of this example is pecked, and it is quite possible that it is a "double-eagle" blade unfinished.

Length, $7\frac{2}{10}$ inches; width of edge, $3\frac{7}{10}$ inches; of haft-space, $1\frac{8}{10}$ inches.

Fig 36. A finely-polished blade, of brown color. The general outline is that of a shouldered hoe-blade. The edge is quite regular, the tapering sides nearly alike, the neck symmetrical, and the faces continuous nearly to the perforation. The butt is flared out at the sides like a crutch, the concave of which is occupied by a narrow, perforated ridge. With this should be compared a specimen from St. Vincent (Timehri, Vol. I, p. 264, Fig. 3). The latter is more ornamented on the upper border, but

the body falls far below that of M. Guesde's specimen. A splendid example from St. Lucia is also in the collection of Mr. Cropper. (Timehri I, 263, fig. 2.)

Length, $7\frac{2}{10}$ inches; greatest width, 4 inches.

FIG. 37.

Fig. 37. This beautiful blade, up to whose form the last few specimens have been leading us, is of a dark-green color, and presents some interesting characteristics. The butt resembles two eagle heads facing outward. The long haft-space or neck widens gracefully outward to where it is joined to the sides by abrupt shoulders. The faces are highly polished and continuous over the entire specimen. The lower side of the edge has been broken and reground.

Length, $9\frac{4}{10}$ inches; greatest width of blade, $4\frac{7}{10}$ inches; greatest width of haft-space, $2\frac{7}{10}$ inches.

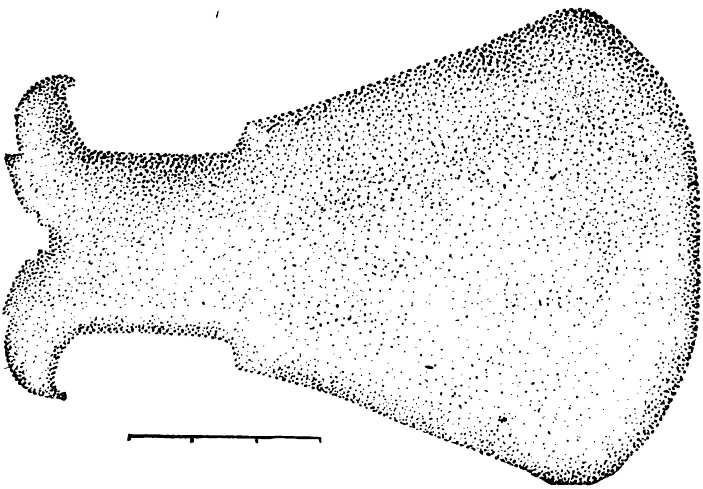


FIG. 38.

Fig. 38. A massive and graceful blade of dark sooty-brown patina. It is in perfect preservation, highly polished, and almost perfectly symmetrical. The butt has the double eagle head, the crests forming a gradined depression in the center. The haft-space or neck has nearly parallel sides, connected with the body by shoulders. The sides spread rapidly outward to meet the broad, finely curved edge.

Length, $11\frac{2}{10}$ inches; width of edge, $7\frac{8}{10}$ inches; top of blade, 4 inches; width of shank, 3 inches; width of butt, $5\frac{2}{10}$ inches.

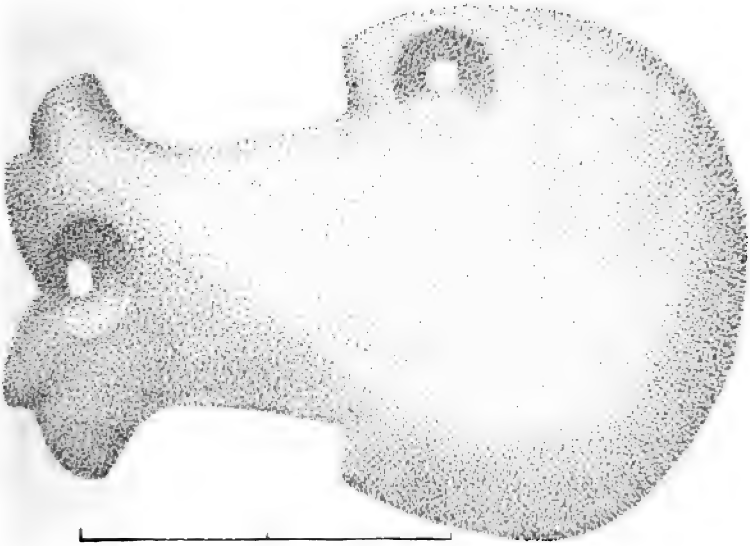


FIG. 39.

Fig. 39. An elaborate blade of deep brown color. This specimen really belongs to three of our classes. The butt is two-beaked and perforated, the beaks with long, prominent crests, (Fig. 38). There is no wide extension of these beaks, however, and the long, tapering haft-space or neck is abruptly shouldered. The body is of the meat-chopper form to be seen further on (Figs. 116–118). Its upper side has the coun-

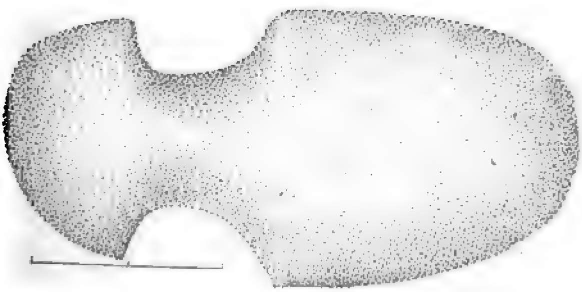


FIG. 40.

tersunk perforation to be observed on several specimens in this collection.

Length, $6\frac{3}{10}$ inches; width, $4\frac{1}{2}$ inches.

Fig. 40. A double-edged blade of rich brown color. The butt is large and irregularly rounded. The lateral notches are deep and long, giving to the object the contour of a shoe-sole. The curved sides approach each other, reducing the edge to a very narrow line. The faces, indeed, are continuous, but this is the only mark in common with its predecessors. The following examples in this section will all exhibit striking individualities.

Length, $6\frac{7}{10}$ inches; greatest width, 3 inches; width of neck, $1\frac{1}{2}$ inches.

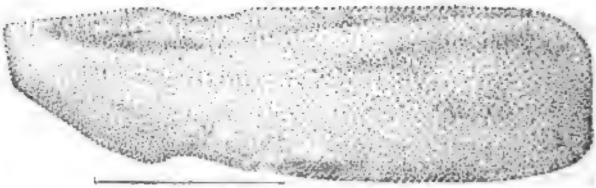


FIG. 41.

Fig. 41. A long and slender blade, of light brown color. Indeed, we have here something like a true northwest coast adze. The butt is wedge-shaped. The hafting space consists of a shallow notch on either side and a groove along one side. The faces are flattish and the sides are so inclined as to give a slight curve to the whole blade.

Length, $6\frac{8}{10}$ inches; width, $1\frac{8}{10}$ inches.

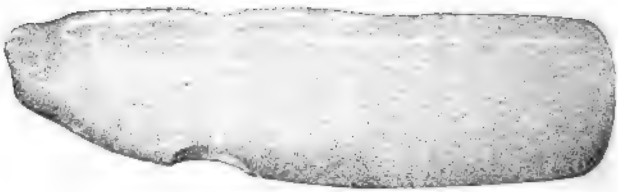


FIG. 42.

Fig. 42. A blade of reddish brown color. It is long, narrow, hollowed on one side, and slightly notched on the other. It resembles Fig. 41, but it is more graceful and brighter colored.

Length, $6\frac{3}{10}$ inches; width, $1\frac{8}{10}$ inches; notch, $1\frac{7}{10}$ inches from the top.

Fig. 43. A two-edged blade, of dark brown color. This object needs only a pierced cylindrical short axis to bring it into formal relationship with the North American ceremonial tomahawks.

Length, $2\frac{4}{10}$ inches.

Fig. 44. An unique blade, of dark brown color. This specimen is noticeable for its very long butt and short blade, the former being twice the latter. The surface is also quite rough, the result of pecking; a kind of manipulation very rare in M. Guesde's edged specimens.

Length, $3\frac{9}{10}$ inches; width of edge, $1\frac{8}{10}$ inches.

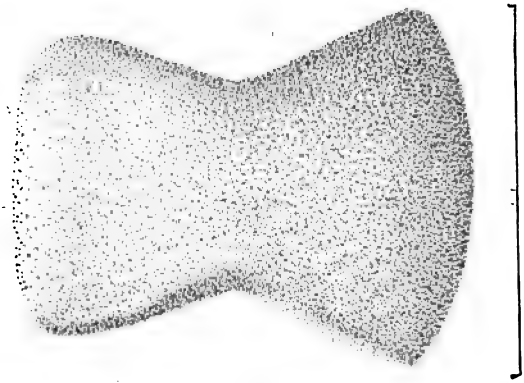


Fig. 43.

Fig. 44.

Fig. 45.

Fig. 45. In this specimen we are getting farther from the preceding examples, the common bond being a continuous surface. This blade is black and presents three edges of different form. The lower resembles that of an axe, the two upper ones are different from the lower and from each other. It would not be difficult to lash this blade to a handle, but the form is very rare.

Length, $4\frac{3}{10}$ inches; greatest width, $3\frac{2}{10}$ inches.

Fig. 46. A curiously formed blade of dark color, and highly polished. It is not altogether unlike Fig. 45, the chief peculiarity being the projection upon the upper side. This characteristic does not appear on any other specimen in the collection.

Length, $6\frac{6}{10}$ inches; greatest width, $3\frac{1}{10}$ inches.

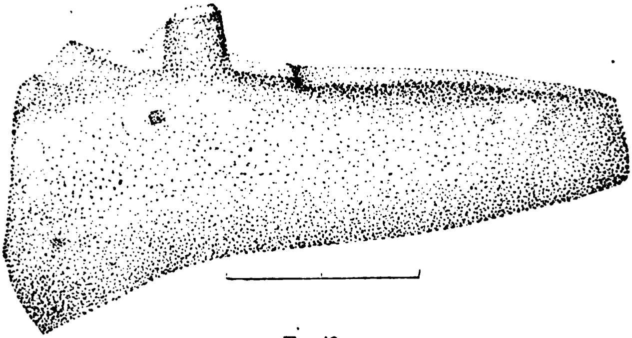


FIG. 46.

Fig. 47. A three-edged blade, of very dark color and veined with white. It resembles Fig. 45, but the workmanship is far superior. The faces and sides are quite flat, giving a rectangular section. One feature is to be remarked, not only here but further on. It is the decided turn of the edge to the bottom, making a pyriform curve.

Length, $8\frac{1}{2}$ inches; greatest width, $4\frac{4}{10}$ inches.

FIG. 47.

IV. BUTT DISTINCT, FACES NOT CONTINUOUS.

The next form of blade to be considered is that in which the butt or head is distinct. This implies a more definite hafting-space, an encircling groove or neck of some kind rather than antero-posterior notches or concavities. It will be seen by running along the members of this section that there are gradations of form, and that this idea of a separate butt is not co-ordinated with any especial kind of haft-space, sides, faces, or edge. Commencing with the simplest type of ax, we pass

through one series of forms to the graceful patu-patu; through another, shouldered variety, to the chopper-knife pattern.

It must be repeated that no such designs of classification are here attributed to the ancient Antillians. They may or may not have been dominated by them. We are only looking at three forces compounding and resolving to bring about a great variety of results, according to the influence of each in any example. These forces are the nature and original form of the pebble, the type-form into whose neighborhood the artist aimed to come, and that sense and pride of achievement which rules in the savage and civilized bosom alike.

FIG. 48.

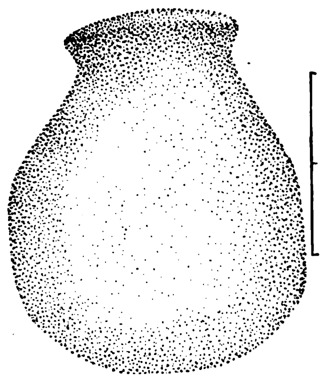


FIG. 49.

Fig. 48. An asymmetrical tongue-shaped blade of gray-brown color. The butt is nearly flat. The groove is very shallow on the faces and deeper on the sides. The latter are not curved alike, a feature quite common in these West Indian specimens. From Canoe.

Length, $4\frac{3}{10}$ inches; width, $2\frac{2}{10}$ inches.

Fig. 49. A very common type, of chocolate-brown patina. The butt is quite flat and bounded by a sharp rim. The haft-space or neck has no boundary below, and the sides are continuous with the edge. These fea-

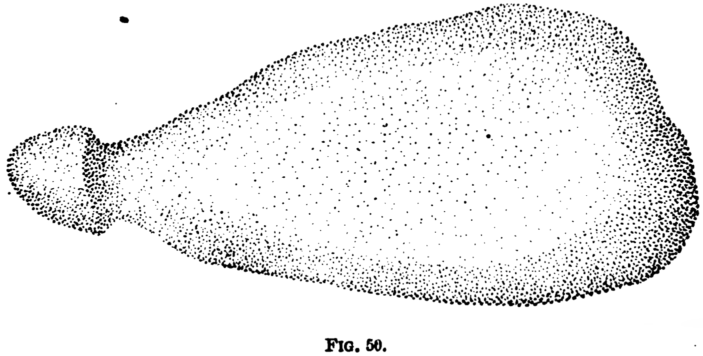


FIG. 50.

tures, with greater or less rudeness, are characteristic of the class now under consideration. From Abymes.

Length, 4 inches; width of neck, $1\frac{7}{10}$ inches; of blade, $8\frac{3}{10}$ inches.

Fig. 50. A very unsymmetrical mĕrĭ-shaped blade of seal-brown color. The butt is conoid, with irregular base, and overhangs like a champignon. The pyriform outline, to be subsequently considered, is quite marked in this specimen. The edge is oblique and very irregular.

Length, $7\frac{1}{2}$ inches; greatest width, $3\frac{4}{10}$ inches; least width, $\frac{9}{10}$ inch.

Fig. 51. An unique blade, semi-ovoid in shape, made of smooth ma-

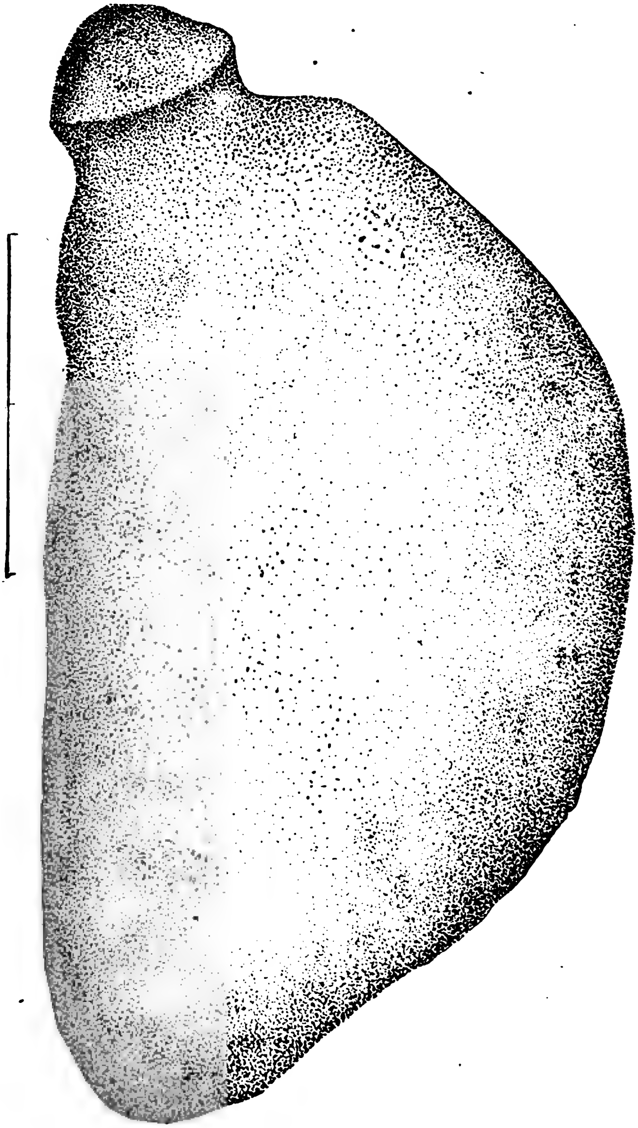


FIG. 51.

terial of a dark brown color. M. Guesde compares the edge with that of a yataghan. In American archæology its general outline is that of the "woman's" knife, so common in collections of Eskimo implements. The latter are mere blades of slate, to be inserted into a grooved handle. In a large collection of these in the National Museum there is a great diversity in the method of attaching a handle.

Length, $6\frac{6}{10}$ inches; width, $3\frac{1}{2}$ inches; width of groove, $1\frac{1}{10}$ inches.

Fig. 52. A very plain blade, of deep brown color. It consists of two elements—the rounded butt, bounded by a much fainter line than the drawing shows, and the right portion, conforming to the type we are now considering. The asymmetry of sides and edge is again thrust prominently into view. This type is said by im Thurn to occur in remarkable abundance in St. Lucia and St. Vincent.

Length, 8 inches; greatest width, $4\frac{7}{10}$ inches.

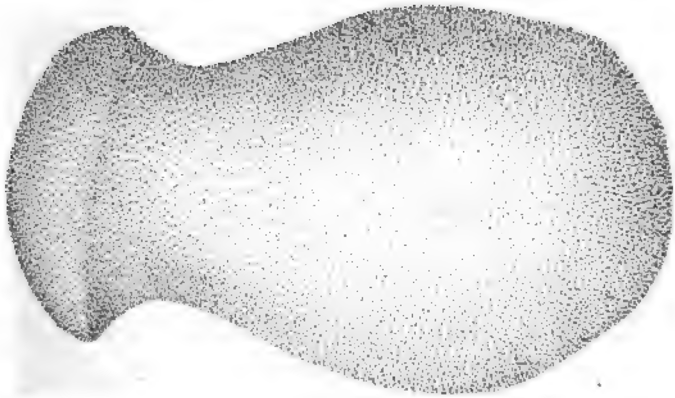


FIG. 52.

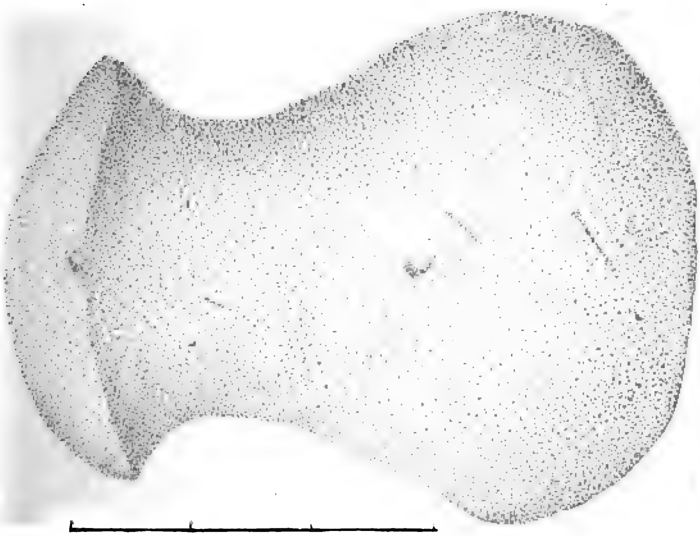


FIG. 53.

Fig. 53. A very gracefully outlined blade, of drab material. The butt is gently rounded and bounded by a trenchant rim, whose plane is curved upward in the middle. All the other parts are continuous. The sides, however, remind us how averse the ancient Antillians were to symmetry.

Length, $5\frac{8}{10}$ inches; width, $4\frac{3}{10}$ inches.

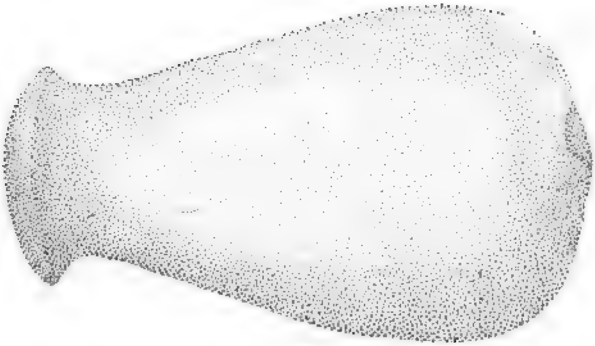


FIG. 54.

Fig. 54. This figure represents a large and beautiful blade, very heavy and close-grained, and black in color. It would take a strong arm to wield this implement. In shape it approaches still nearer to the New Zealand mērĭ, but the handle is still too wide. The sides are very much alike. From St. Rose.

Length, $9\frac{7}{10}$ inches; greatest width, $5\frac{7}{10}$ inches; neck, $2\frac{8}{10}$ inches.

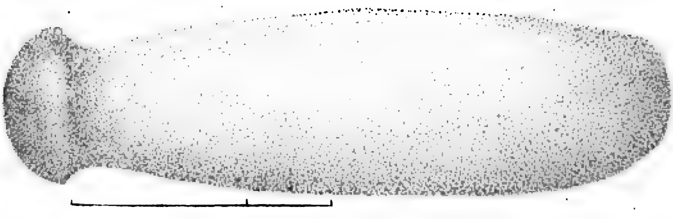


FIG. 55.

Fig. 55. A long, thin blade of peculiar pattern, and dark brown in color. The butt is large in proportion to the body. The two sides do not quite correspond, and the edge is adapted to this fact, showing just the slightest tendency to the bill-hook variety, to be described further on.

Length, 8 inches; greatest width, $2\frac{2}{10}$ inches.

Fig. 56. A broad, mērĭ-shaped blade of dark surface. The butt is small, rounded, and overhanging. The lower side is much more prominent. The whole appearance of this specimen indicates that it came to its present shape without much artificial modification.

Length, $7\frac{6}{10}$ inches; width, $4\frac{7}{10}$ inches.

Fig. 57. A broad, mĕrĭ-shaped blade of dark seal-brown color. Excepting the slight fractures on the face, the implement is perfect, unless the truncated portion on the lower side at the edge is an afterthought,

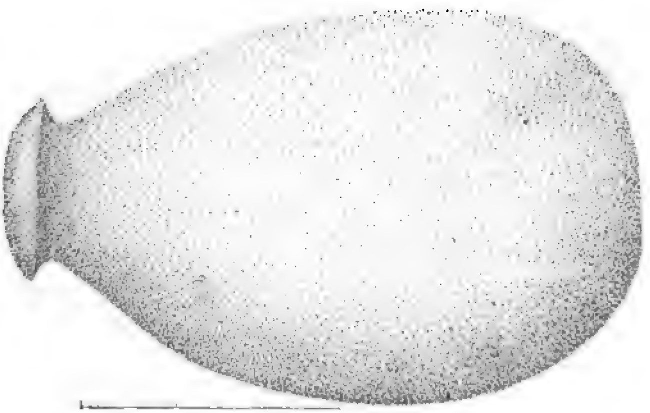


Fig. 56.

having been ground off to hide a break. We are now approaching the real méri and may imagine ourselves in the neighborhood of New Zealand.

Length, 5 inches; width, $3\frac{1}{2}$ inches; neck, $1\frac{8}{10}$ inches.

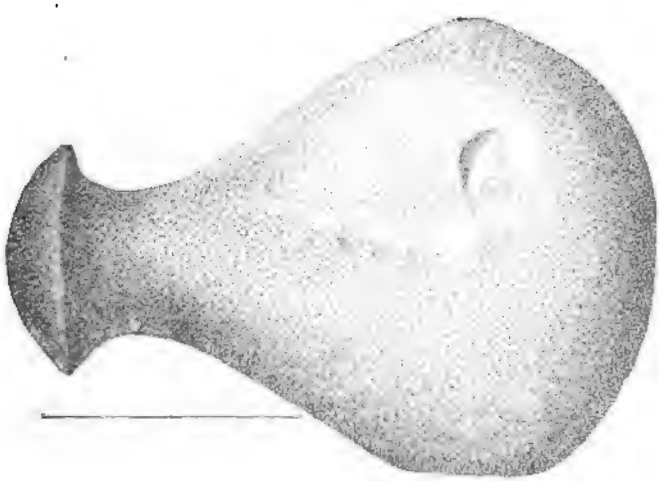


Fig. 57.

Fig. 58. A beautifully polished blade of light brown color. It is méri-shaped. The butt is gently rounded, bounded by a ridge, curved transversely in a "line of beauty," and ornamented with nine mammiform protuberances. The other elements form one continuous and graceful outline, save a slight fracture on the right extremity of the edge.

Length, $6\frac{2}{10}$ inches; width, $4\frac{4}{10}$ inches; width of neck, $2\frac{1}{10}$ inches.

Fig. 59. A broad, mĕrĭ-shaped blade of bright brown color. The

butt is very slightly rounded and the neck or handle almost long enough for the hand. There is a very slight division in this specimen between the butt and the neck, and between the sides and the edge.

Length, 8 inches; width, 6 inches.

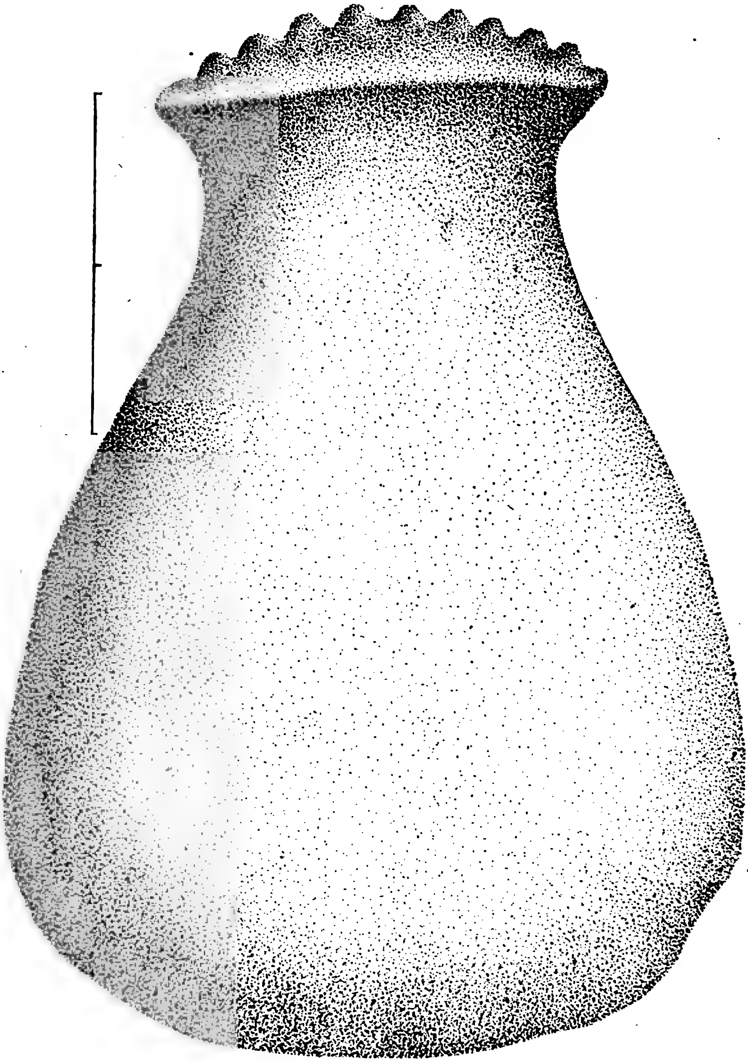


FIG. 58.

Fig. 60. This blade of green and brown mottled appearance approaches nearer still to the typical mĕrĭ. The butt is formed by a bent surface having a rim about two millimeters in thickness. The neck or handle is nearly three inches long. The straight and the bulging side can readily be seen here, and the edge shows good signs of use. From Lamenton.

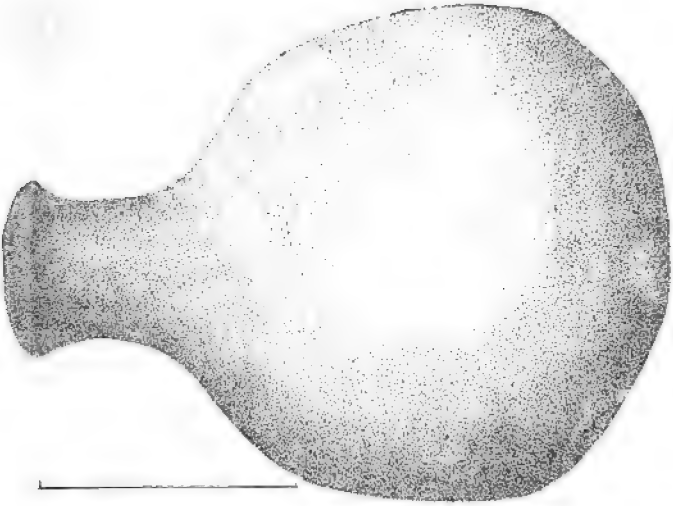


FIG. 59.

Length, $7\frac{2}{10}$ inches; width of butt, 2 inches; of neck, $1\frac{3}{10}$ inches; of blade, $3\frac{6}{10}$ inches.

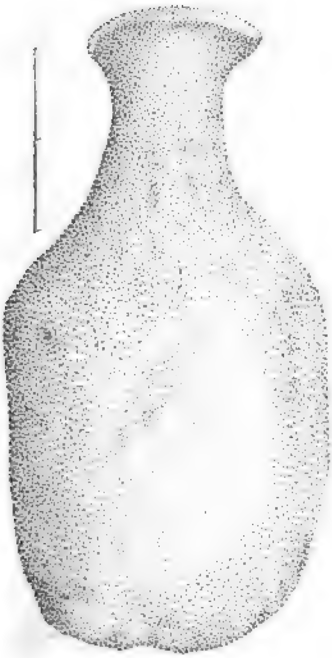


FIG. 60.

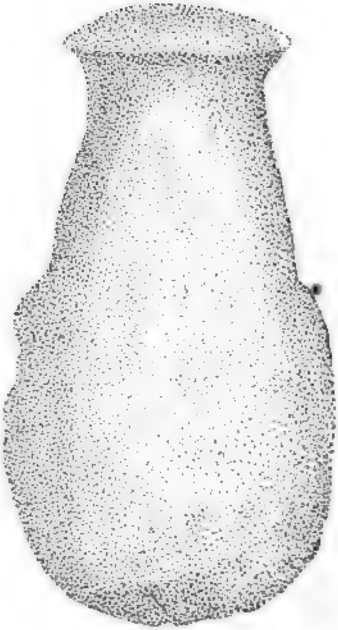


FIG. 61.

Fig. 61. A very finely polished, massive blade of black color. The méri shape is apparent, but the general appearance is too stout and broad. Especial attention is called to the unlikeness of the sides. The

right is not unlike many others, with a tapering neck shouldered at the side. The left side repeats this character, adding sinuosities on the side below the neck. The edge is quite symmetrical, and the specimen is a very attractive one. From Marie Golante.

Length, $9\frac{1}{2}$ inches; width of butt, $3\frac{9}{10}$ inches; of neck, 3 inches; greatest width of blade, $5\frac{6}{10}$ inches.

Fig. 62. New Zealand mĕrĭ, introduced here by M. Guesde to illustrate the type and climax of blade which is now under consideration. The material is a green jadoid. Gustav Klemm draws attention to the

FIG. 62.

FIG. 63.

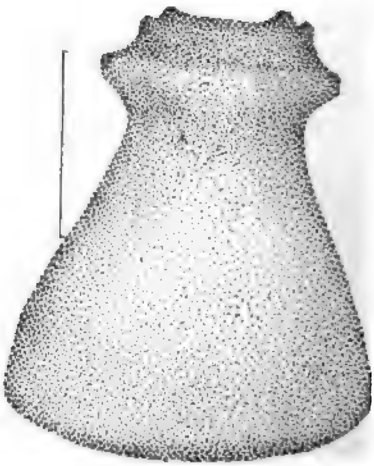


FIG. 64.

fact that on the coast of New Zealand extensive layers of flat and blade-shaped pebbles of nephrite furnish the natives with ready materials for the fabrication of hatchets, knives, and other implements. No less true is it that in the West Indies, where no calcareous flint occurs, "Nature, the kind old nurse, took her child upon her knee," and taught him to utilize the materials at hand for their convenience and happiness. The term mērĭ (pronounced may-ree) is preferred to patu, the latter term meaning generically any striking weapon.

Length, 13 inches; width, $3\frac{4}{10}$ inches.

Fig. 63. A blade of slaty-black material. The butt is very small and knob-like, and the haft-space shallow. The sides widen out unevenly, so as to give the contour of a scapula or hand-ax. The form is rare, and serves to connect the ruder méri with the two following examples.

Length, 6 inches; width, $3\frac{8}{10}$ inches.

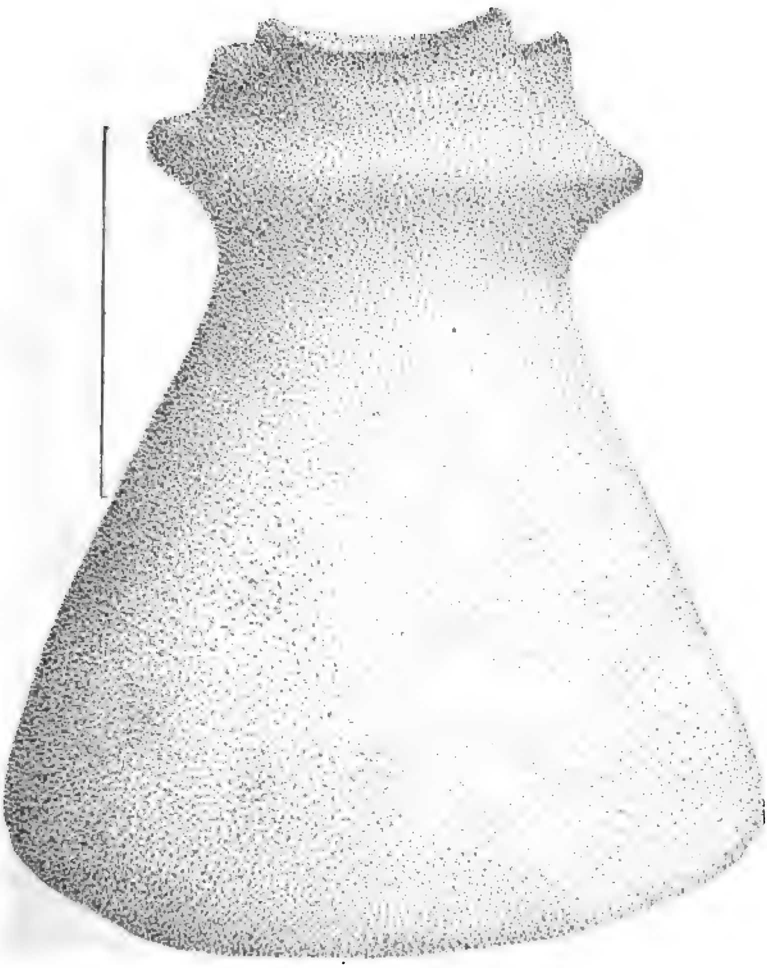


FIG. 65.

Fig. 64. A blade of the hand-ax type, of a bright brown patina. The butt is gradined in a peculiar manner and bounded by a prominent ridge. The work of ornamenting the butt is admirably done, giving the appearance of hollow dishes fitting one into another. The unsymmetrical sides are also visible here, although the implement does not show much use. A similar butt and edge with parallel sides is seen in a specimen from St Vincent, belonging to E. B. Griffith (*Timehri*, III, p. 111, Fig. 5), and a very much ruder specimen in Fig. 1, p. 264, of Volume I.

Length, 5 inches; width of edge, 4 inches; of neck, 2 inches.

Fig. 65. A finely polished blade of brown color. This is one of the most beautiful specimens in the collection. The butt has a bounding ridge very prominent, the curved surfaces above and below nearly alike. Two gradines above this are carved in the shape of an opera hat or the sheath of the lace palm doubled in and dented on the top. The unlike sides are very well seen here.

Length, $5\frac{1}{10}$ inches; greatest width, $4\frac{1}{10}$ inches.

Fig. 66.

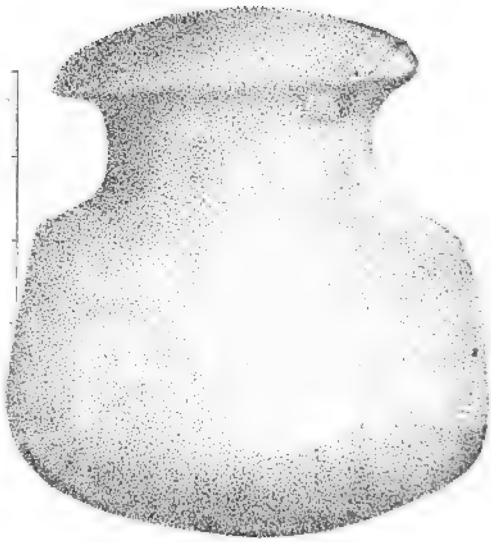


Fig. 67.

Fig. 66. A very common form of blade, of light brown color. The butt is coarsely made and slightly ridged. The hafting or lateral notches very unlike, which also causes asymmetry in the sides and edge. This specimen will serve as an introduction to what may be called the meat-chopper type, more fully developed further on. From Marie Golante.

Length, $4\frac{1}{2}$ inches; width of blade, $3\frac{8}{10}$ inches.

Fig. 67. A very smoothly finished blade, but of the same type as the last and very dark in color. Without ornamentation or wear, the parts are all strikingly distinct.

Length, $5\frac{9}{10}$ inches; width, $4\frac{7}{10}$ inches.

Fig. 68. A very common form of blade of seal-brown color, seeming to have been cut from a simple pebble by excavating an encircling groove, hooded above and running out on the sides and faces. The difference of depth in the groove between the sides and the faces is well marked by the contour of the neck on its lower border. The asymmetry so frequently noticed is very strong here.

Length, $2\frac{2}{10}$ inches; width, 2 inches.

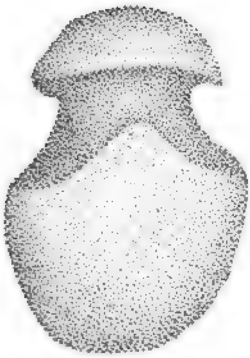


FIG. 68.

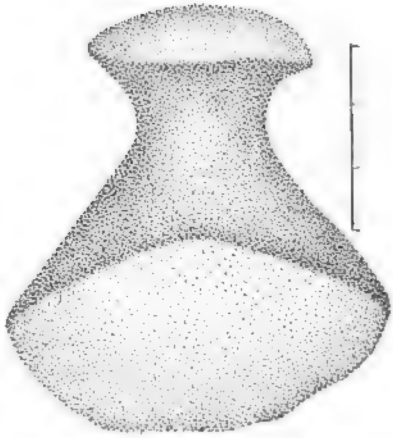


FIG. 69.

Fig. 79. A much worn blade of black color. The original shape may have been like a mērĭ, but constant grinding has brought it more to the chopper form.

Length, $3\frac{1}{2}$ inches; width, $3\frac{1}{10}$ inches.

Fig. 70. A much worn blade of black color, quite like the modern chopping knife, or Eskimo woman's knife. The butt is rough and small, the neck long and tapering, suddenly widening below to the edge. From one of the islets of Pointe-à-Pître.

Length, $3\frac{2}{10}$ inches; neck, 1 inch; width of blade, $3\frac{6}{10}$ inches.

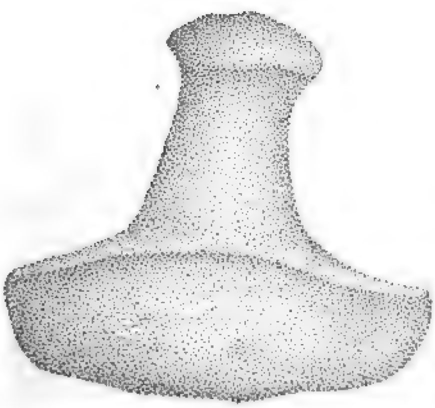


FIG. 70.

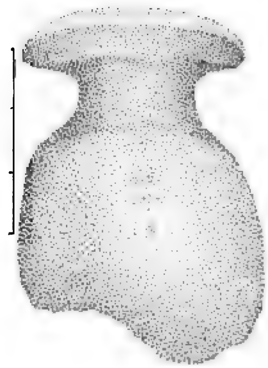


FIG. 71.

Fig. 71. A blade of very dark color, which in outline resembles a shoemaker's hammer. The butt is nearly as wide as the blade, neatly curved, and bounded by a flat border. The neck is gracefully curved and hooded. The faces are flat as if much worn. A portion of the edge is wanting. From Marie-Golante.

Length, 6 inches; width of blade, $4\frac{1}{2}$ inches; of neck, $1\frac{9}{10}$ inches; of butt, $3\frac{8}{10}$ inches.

Fig, 72. A very symmetrical and substantial looking blade of dark brown color. The lines on this specimen are all nearly true, but the noticeable feature is the appearance every where of sharp boundaries. The butt is bordered below by a flat band, and a chamfered surface on both faces bounds the haft-space or neck and the edge. Here we have the chopper shape completely developed.

Length, $5\frac{8}{10}$ inches; width, $4\frac{1}{2}$ inches.

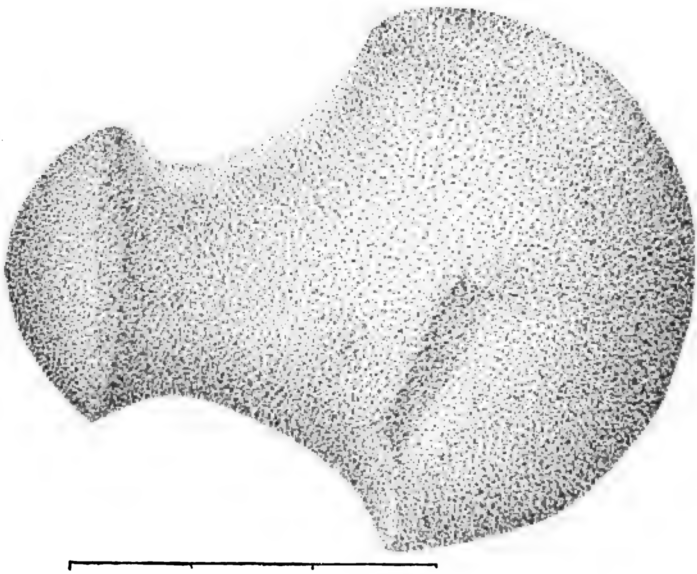


FIG. 72.

Fig. 73. A chopper-shaped blade, very thin and well preserved, of brown color. The lines on this specimen are still more sharply defined, but the edge has no bevel. Especial notice should be taken of the square sides, giving a true rectangular section to the haft-space, and the hooks at the ends of the edge.

Length, $3\frac{4}{10}$ inches; width of butt, $1\frac{8}{10}$ inches; of neck, $1\frac{2}{10}$ inches; of blade, $4\frac{6}{10}$ inches.

Fig. 74. An ornamental blade of the chopper-knife variety, and in color a seal brown. By comparing this with the last specimen an advance in elaboration will be noticed in the curves and gashes at the extremities of the edge.

There are several chopper-blades in the collection, reminding one of the Gaveoe Indians of Brazil, mentioned in Flint Chap. p. 141, quoted from Proc. Soc. Antiquaries, 128 S, vol. 1.

FIG. 73.

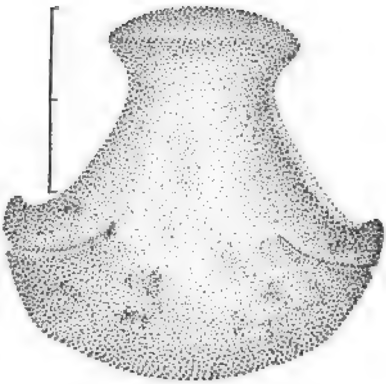


FIG. 74.

Length, 4 inches; greatest width, $4\frac{1}{10}$ inches; least width, $1\frac{8}{10}$ inches.

Fig. 75. A very beautiful blade of light brown color. The butt has a sharply-defined ragged border. The terraced appearance before noticed is here visible, but curtailed, the middle ridge not being continuous. The neck slopes gracefully to the edge, the extremities of which rise out of the sides so as to give the effect of a thin edge inserted. There is not the slightest defect in this example.

Length, $4\frac{4}{10}$ inches; width, $4\frac{1}{10}$ inches.

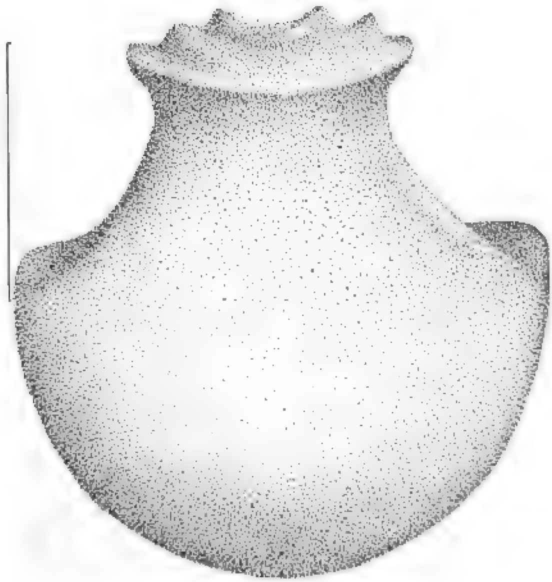


FIG. 75.

Fig. 76. A highly-polished blade, of dark, sooty brown patina. The elements of several previously-mentioned blades are here to be seen. The butt has the double eagle head with central perforation, seen in figure. The tapering haft-space has been frequently mentioned, while the triple scallop with perforation of figure 39 is here bilateral. This example will form the climax of this type of blades, and it is well worthy to hold that position.

Length, 9½ inches; width of blade, 8 inches; of haft-space below, 4½ inches; width of butt, 4$\frac{3}{10}$ inches.

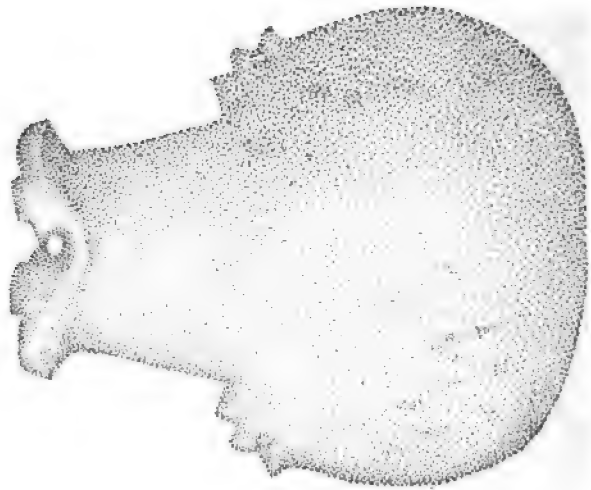


FIG. 76.

V. BLADES WITH HOOKED EDGES.

In the small series of blades now to be presented, a characteristic previously noticed as being more or less apparent in the work of those barbaric peoples who work without compass or rule, will be brought more prominently into view. Indeed, to use the language of biology, varietal marks become fixed and specific. Another wonderful law of biology is also noticeable. It is this, that no part of a structure can undergo any great modification without profoundly affecting many other parts. Nature has changed her key-note and the whole composition must be played on another scale. It is hard to guess what this bill-hook form in so many bladescan signify. In vain we turn to Polynesia or Queen Charlotte Sound for help. In higher civilization the bill-hook does good service, first in the hands of the soldier, then in those of the hedger. Coming to view in this Carib environment we are left to wonder. Most of M. Guesde's specimens of this class are very large, massive indeed, and most carefully polished. We shall be able to show a gradation of form beginning with suggestion and ending with unmistakable reality.

Fig. 77 A massive blade of black color, the largest specimen in M. Guesde's collection. The general type is common enough in the Antilles, and indeed may be seen almost everywhere. However, the two sides

FIG. 77.

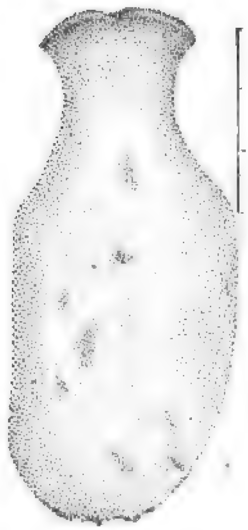


FIG. 78.

are decidedly unlike, the right nearly straight, the left bulged out; and by this fact the edge is so modified that the left is continuous with the side, and the right nearly arrested by a corner.

Length, $16\frac{2}{10}$ inches; greatest width, 6 inches.

Fig. 78. A specimen resembling the last described, of light gray-brown color. The butt is not elevated, and its band is emarginated at the sides. Here we may see a little greater modification from the type by the in-

curving of the left side and a nearer approach to a hook below. The surface is finely polished and the combination of marks unique.

Length, 8½ inches; width of butt, $2\frac{6}{10}$ inches; of blade, $3\frac{8}{10}$ inches.

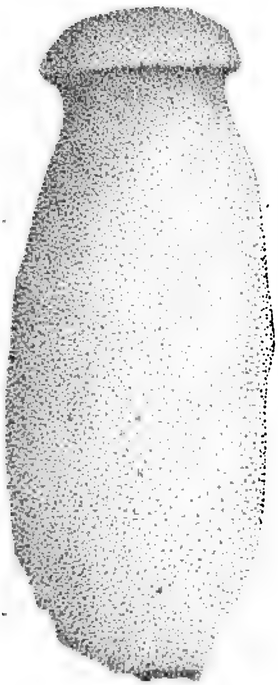


FIG. 79.

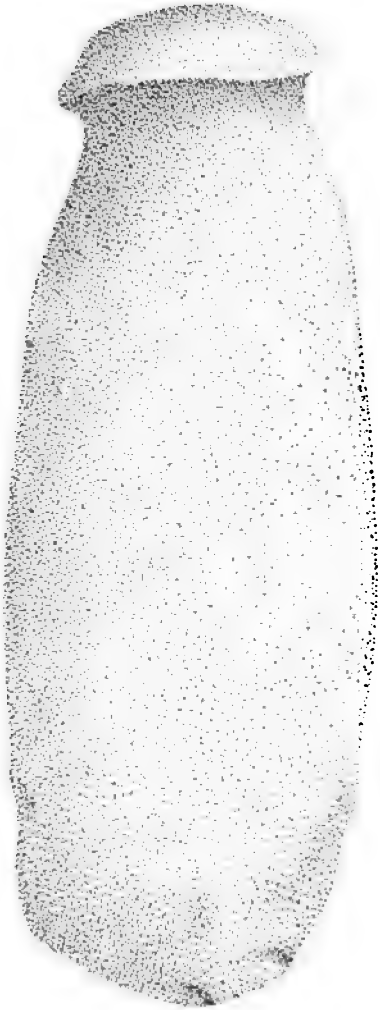


FIG. 80.

Fig. 79. A massive blade of brown color. The lower border of the rounded butt is nearly square with the axis of the specimens, and evenly rimmed; the sides, however, are very different. The break at the most important point at the bottom prevents our knowing just how the hook was finished.

Length, 12½ inches; greatest width, 5 inches.

Fig. 80. A massive blade, of dark brown color. The lower margin of the butt is not horizontal, its facial outline forming a sigmoid curve.

In some other examples the butt is modified by the lateral asymmetry. The point of coalescence of the left side with the edge is quite distinct although it is not yet quite a hook.

Length, 11 inches; greatest width, $4\frac{1}{10}$ inches.

FIG. 81.

Fig. 81. A beautifully polished massive blade, of light drab color. The inner edge of the butt is nearly straight and banded. In the other parts our type is carried out, the only advance being the change of curve near the edge at the lower side. The specimen is highly finished and would be an attractive object in any collection.

Length, $13\frac{9}{10}$ inches; greatest width, $4\frac{9}{10}$ inches.

FIG. 82.

Fig. 82. A giant blade, of mottled color, resembling marble. Here will be seen the bill-hook type quite fully developed. The sloping butt, the totally unlike sides, and the extension of the edge well beyond the line of the lower side are all noteworthy. The remains of fluting, visible all around the sides and edge, stamp this specimen with a form to which Nature has not contributed a suggestion; they also show how such implements were constructed.

Length, $14\frac{7}{10}$ inches; greatest width, $6\frac{2}{10}$ inches.

Fig. 83. A massive blade of light brown color and highly polished. The small, rough butt belongs to quite another order, indeed, in this

respect, the specimen ranks very low. Aside from this, however, it is an attractive example of its type. The bulging of the hooked side is noteworthy but not unique.

Length, $10\frac{1}{2}$ inches; width, $4\frac{3}{4}$ inches.

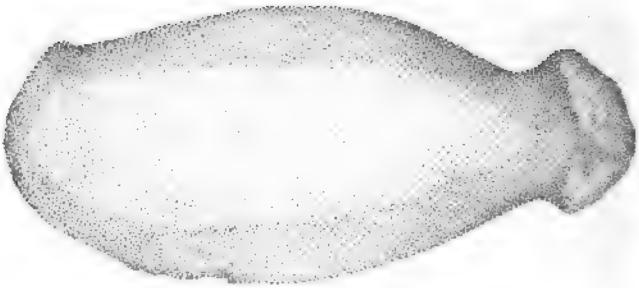


FIG. 83.

Fig. 84. A broken blade, of blackish brown color. It is placed here for the purpose of showing that in archæology a little prediction may be indulged in. In every other particular the specimen resembles the bill-hook type. Should the missing portions be found, therefore, the upper side would pass on in a continuous curve with the edge to the lower extremity of the under side, where it will form an angle or a hook.

Length, $11\frac{1}{2}$ inches; greatest width, $4\frac{3}{10}$ inches.

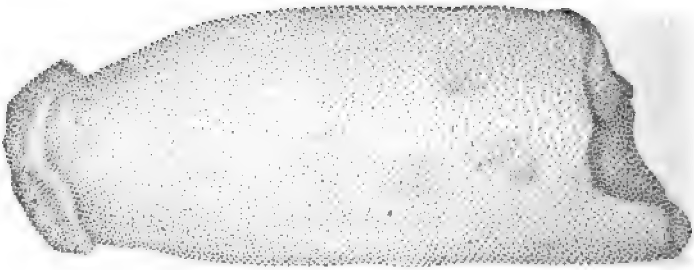


FIG. 84.

Fig. 85. A smaller bill-hook or pyriform blade, of light brown color. The rudeness of the butt and groove is remarkable. The other lines are very graceful, especially that of the upper side.

Length, $4\frac{2}{10}$ inches; width $1\frac{5}{10}$ inches.

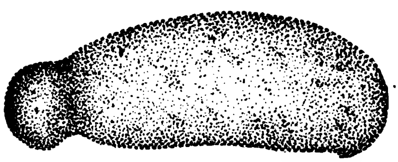


FIG. 85.

Fig. 86. A massive blade, of the bill-hook type, and slate brown in color. The butt still has some eccentricities, more than compensated for, however, by the elegance of the other portion.

Length, 9 inches; greatest width, 4 inches.

FIG. 86.

FIG. 87.

Fig. 87. A perfect blade, brown in color and of exquisite polish. It is not massive. The butt is horizontal and the hooked side unusually curved. The hook is more decidedly formed in this than in any other members of the class.

Length, $5\frac{2}{10}$; width of blade, 3 inches; neck, $1\frac{5}{10}$ inches.

Fig. 88. A finely-polished blade, of the bill-hook type and of a rich brown color. Aside from the fidelity with which the typical ideas are carried out, should be noted also the change of curve in the edge and

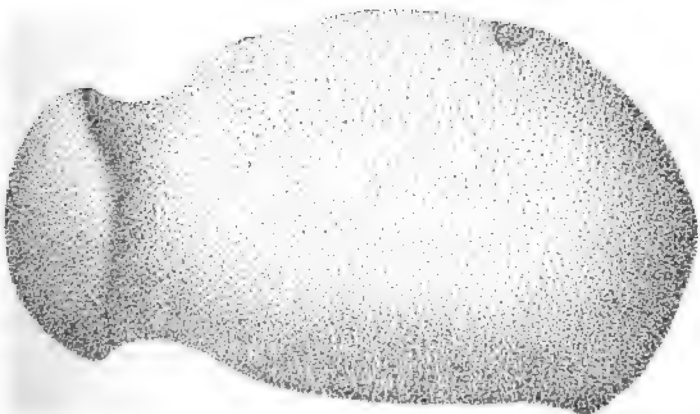


FIG. 88.

in the margin of the butt nearly over it. This is the last specimen of this variety which will receive notice.

Length, $7\frac{8}{10}$ inches; width, $4\frac{3}{10}$ inches.

VI. BLADES WITH ENCIRCLING GROOVES.

The next type of blades embraces many examples in the Antillian area, extending from a very rude form to some of the greatest beauty. The encircling grooves or excavations for hafting in a large series of stone implements will be found to include many geometric figures in other parts of the implements, such as the circle, ellipse, *vesica piscis*, and any of these may have one or two truncations. The grooves will also differ in their position on the blade, in depth, width, and the construction and parallelism of their borders. In the series of hafted hammers, hoes, adzes, and axes in the National Museum at Washington, one can readily perceive that even the savage workman was not shut up to a single device in hafting his tools. Indeed, such is the diversity of methods that one familiar with a large number of specimens learns to pick out localities and nations by the methods used.

Another fact illustrated in this series is the easy transition from useful to highly ornamental forms. Beginning, as Klemm has advised us, with little modified pebbles, we culminate in examples wherein every vestige of nature and use is lost.

Fig. 89. A small blade of blackish color. The very least opportunity is afforded for hafting, but we may refer again to John Evans. Marie-Golante. Neither this nor the following example can fully claim to be a grooved blade.

Length, $1\frac{4}{10}$ inches.

Fig. 90. A small blade of dark brown color. This specimen is a little more highly finished than the last, but the characteristics are identical.

Length, 2 inches.

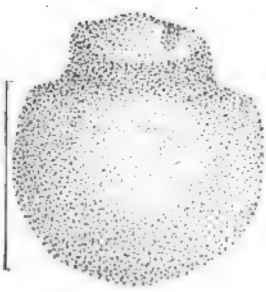


FIG. 89.

FIG. 90.

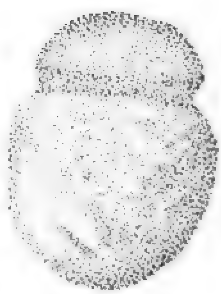


FIG. 91.

Fig. 91. The smallest blade in M. Guesde's collection; light drab color mottled with brown. The groove is now encircling and distinguishes the butt entirely from the body.

Length, $1\frac{1}{2}$ inches; width, $1\frac{1}{10}$ inches.

Fig. 92. A grooved blade of very dark brown color. There is a delightful *negligée* about the lines of this example. There is neither symmetry nor parallelism where either one should be found in a perfect specimen. The marks of much wear are visible on the edge.

Length, $2\frac{3}{10}$ inches.

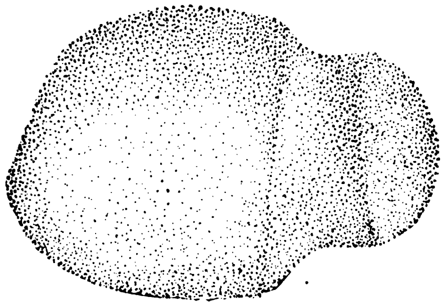


FIG. 92.

Fig. 93. A very irregular blade of light brown color. There is every reason to believe that the only change wrought in the original stone is the groove or neck hooded above and running nearly out below, so as to be undistinguishable from the faces and the ground edge.

Length, $7\frac{1}{10}$ inches; width of edge, $4\frac{1}{2}$ inches.

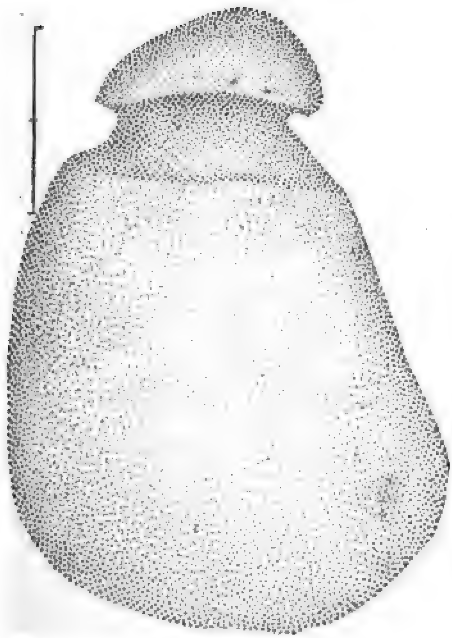


FIG. 93.

FIG. 94.

Fig. 94. A beautifully polished blade of drab color. The type is very similar to that of the last described, but the original stone was more

shapely. Here for the first time we encounter a definitely-cut encircling groove.

Length, $2\frac{7}{10}$ inches; width, 2 inches.

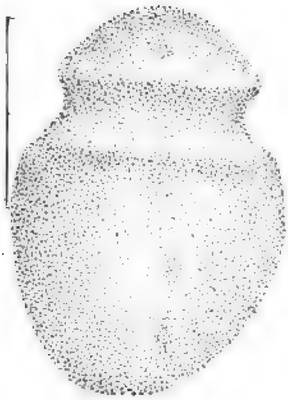


FIG. 95.

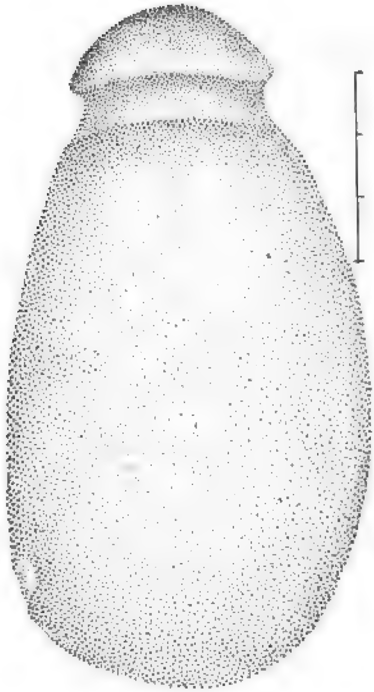


FIG. 96.

FIG. 97.

FIG. 98.

Fig. 95. A grooved blade, of light brown color. The butt is quite symmetrical, the groove uniform and transverse, and the edge nearly regular. The type is common all over the world. From Marie-Golante.

Length, $4\frac{1}{10}$ inches; width, 3 inches.

Fig. 96. A massive blade, with very small head and groove, of very dark brown color. The asymmetry of the sides is noticeable, and there is just a slight hook on the left. This stamps our classification as purely artificial. If we regard the groove we must cast neglect sometimes upon the edge. From San Mahault.

Length, 11 inches; width, 6 inches.

Fig. 97. A grooved blade, of dark slate color. The butt and the body are nearly regular; the former occupying one-third of the object.

Length, 2½ inches.

Fig. 98. A grooved blade, of light brown color. The noticeable feature is the hatchet edge extending on both sides to the groove. The butt is the most finished yet in this class.

Length, $2\frac{1}{10}$ inches.

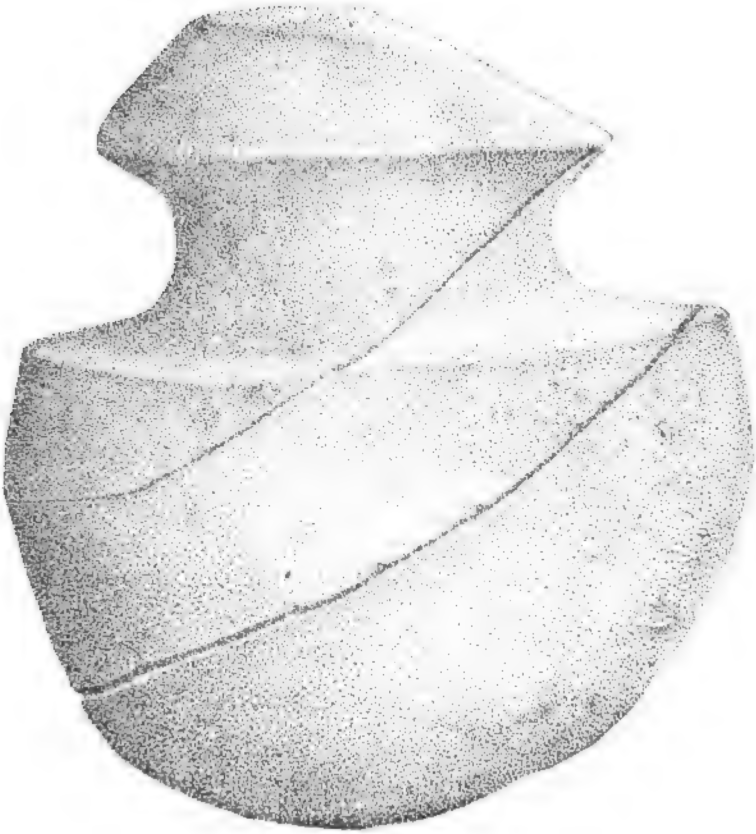


FIG. 99.

Fig. 99. A giant blade, of light brown color. When entire this must have been an imposing object. The butt originally was flat-topped and very symmetrical, the groove broad, deep, and parallel-sided. The body is of the chopper variety mentioned in the last class (Figs. 70 and following).

Length, 10 inches; greatest width, $8\frac{3}{10}$ inches.

Fig. 100. A much worn blade of very light color, showing that it has been "battered by the shocks of doom to shape and use." The conformity to the shape so common in the United States ought to be noticed. The edge and faces are well ground away.

Length, 4 inches; width, $3\frac{8}{10}$ inches.

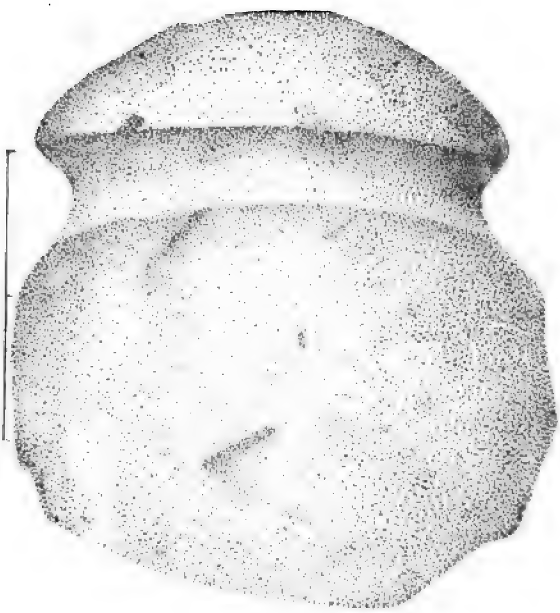


FIG. 100.

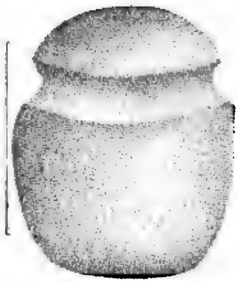


FIG. 101.

Fig. 101. A small grooved blade, which M. Guesde calls a mace. Unless the painting is misleading it is a very pretty, unpretentious example of the small, grooved ax.

Length, $1\frac{4}{10}$ inches; width, $1\frac{1}{10}$ inches.

Fig. 102. A long thin blade of light brown color. The butt is cylindroidal and rough topped. The notch is shallow and the sides are nearly parallel. This is a rare form in the Antillian area.

Length, $7\frac{2}{10}$ inches; width, $1\frac{7}{10}$ inches.

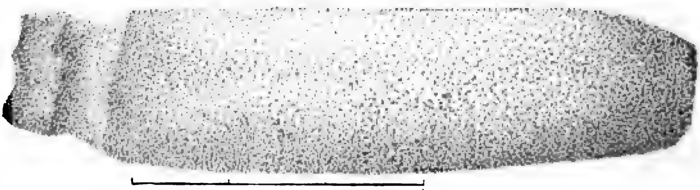


FIG. 102.

Fig. 103. A long slender blade, of blackish color, shaped something like a ten-pin. The butt and encircling groove are one. The long, flat faces terminate in a squared edge.

Length, $6\frac{2}{10}$ inches; width, $2\frac{1}{10}$ inches.

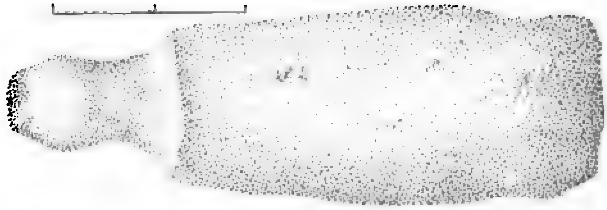


FIG. 103.

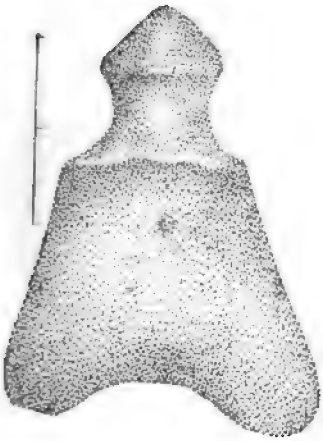


FIG. 104.

Fig. 104. A grooved blade of dark brown color. It resembles Fig. 103, excepting that the butt is more distinct and the sides divergent. The edge is much worn by use, and the concave grinding very uncommon.

Length, 4 inches; width of blade, $3\frac{3}{10}$ inches.

Fig. 105. A very attractive blade of bright brown color. The object shows great age by reason of the grinding which has taken away a portion of the butt and changed the outline of the lower border of the groove. The polish and unbroken condition of a specimen so much worn are remarkable.

Length, $5\frac{6}{10}$ inches; width, $5\frac{1}{10}$ inches.

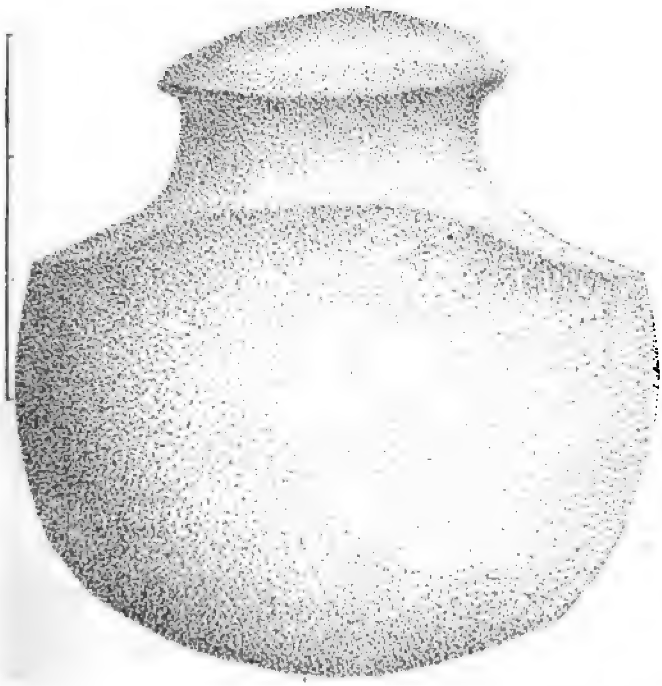


FIG. 105.

Fig. 106. A very smooth and rare form of blade of dark brown. The butt is of the champignon type and has very little boundary below. The two sides are unlike giving the face the appearance of a shoe sole. The edge is also one sided.

Length, $5\frac{7}{10}$ inches; width, $3\frac{2}{10}$ inches.

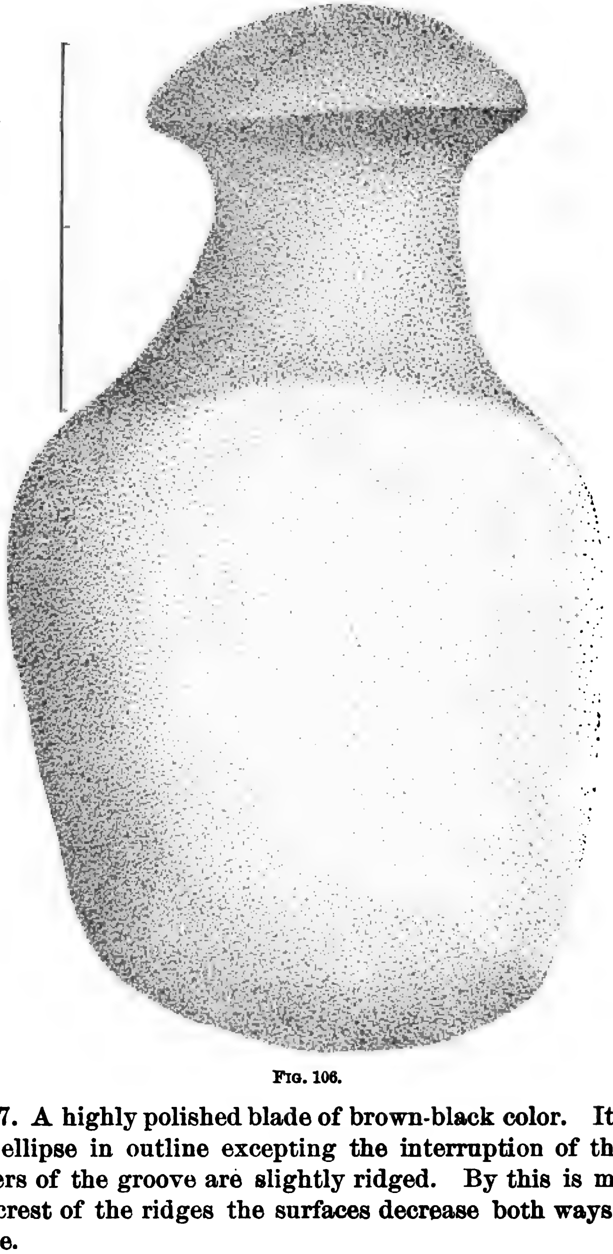


Fig. 106.

Fig. 107. A highly polished blade of brown-black color. It is almost a perfect ellipse in outline excepting the interruption of the groove. The borders of the groove are slightly ridged. By this is meant that from the crest of the ridges the surfaces decrease both ways by a concave curve.

Length, $5\frac{1}{10}$ inches; width, $3\frac{1}{2}$ inches.

Fig. 108. A polished blade of bright brown color. This specimen, though not extraordinary in form is one of the most attractive in the collection of M. Guesde. It could hardly be more regular if it had been formed in a lathe. The shield shaped faces are rare, and the shouldering of the faces worthy of notice.

Length, 7 inches; width of neck, 2 inches; of blade, $4\frac{1}{2}$ inches.

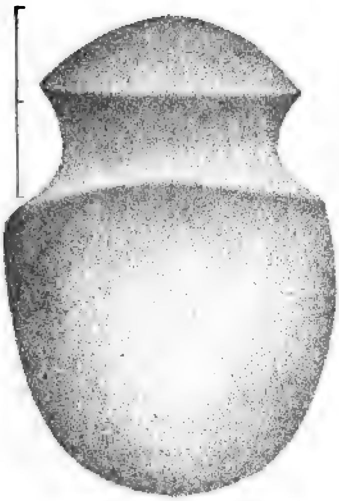


FIG. 107.

FIG. 108.

Fig. 109. A double-edged, grooved blade, of light brown color. The form is common enough elsewhere, but certainly it seems to be the first appearance in this area of an ax with both ends alike.

Length, $7\frac{2}{10}$ inches; width, $3\frac{1}{10}$ inches.

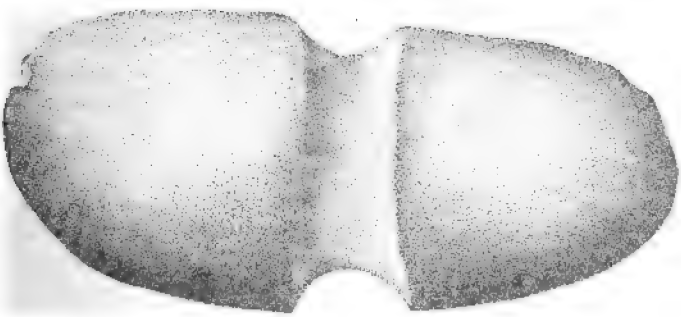


FIG. 109.

Fig. 110. A beautifully polished blade, of bright brown color. In shape it resembles a butcher's cleaver, well worn. It should be compared with figures 77 to 88. In the curve of the right side the bill-hook form recurs, and, in this respect, this specimen should have been described in the last chapter.

Length, $7\frac{7}{10}$ inches; greatest width, $4\frac{2}{10}$ inches.

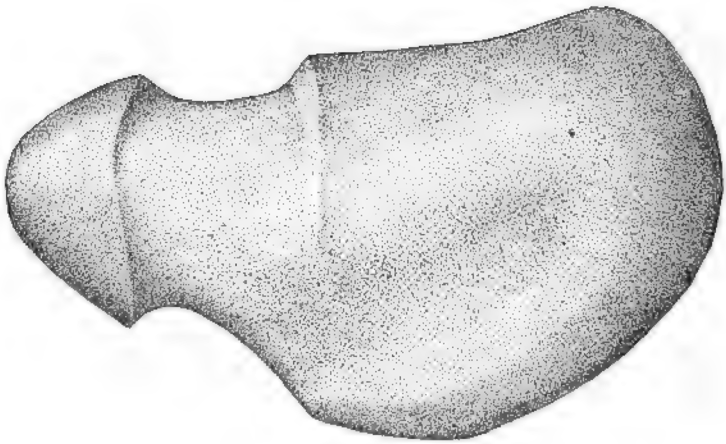


FIG. 110.

Fig. 111. A massive blade of slaty gray color. This specimen also by its edge goes to the bill-hook type. (See figures 77 to 88.) The sinuate groove and broken sides should be noticed. It is customary to take the groove on axes largely into account, but in this example, as well as in figures 93, 94, 96, and 110, the salient feature is the twisting of the contour of the implement to one side, forming a decided hook in many examples.

Length, 12 inches; greatest width, $4\frac{6}{10}$ inches.

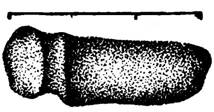


FIG. 112.

Fig. 112. A grooved blade of gray color. This form is so common in the United States and so absolutely unknown in the West Indies that the probabilities are against its genuineness. M. Guesde, however, is our authority for placing it in Guadeloupe. Looking over a large number of ax-blades from the United States, one is struck with the prevalence of this particular type, with the left boundary of the neck ridged up on both sides, in areas widely separated.

Length, $3\frac{2}{10}$ inches; width, $1\frac{2}{10}$ inches.

Fig. 113. A grooved ax of reddish brown color. It is of a very common pattern, excepting the bulging of the right side, which gives it the appearance of having been cut out for a shouldered handle. (See Fig. 118.)

Length, $5\frac{1}{2}$ inches; average width, $2\frac{1}{10}$ inches.

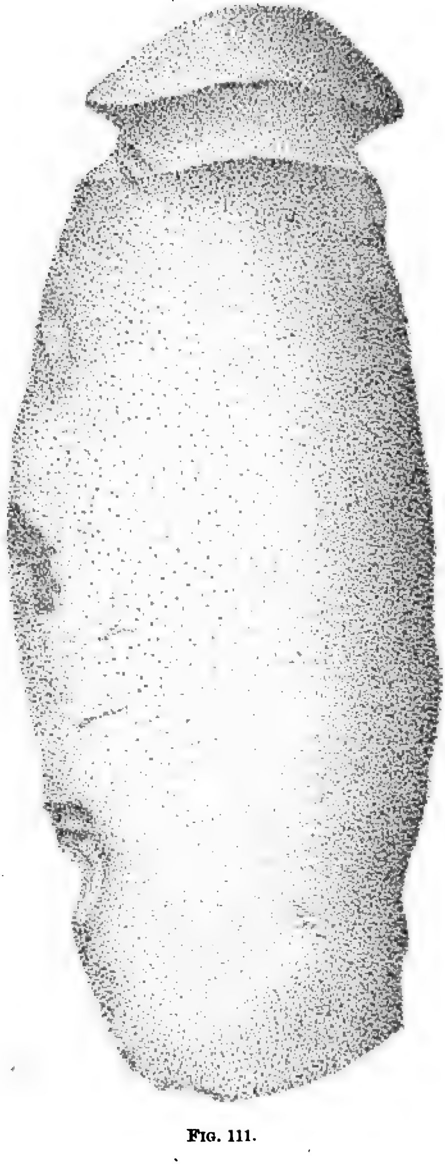


FIG. 111.

Fig. 114. A gracefully formed blade of very dark material. The remarkable characteristics are the double furrow and cup ornament of the butt, the elongated groove, and the tongue-shaped faces. The workmanship is very fine.

Length, $4\frac{8}{10}$ inches; width of blade, $2\frac{7}{10}$ inches.

Fig. 115. A beautiful blade of greenish brown color. The remarkable features are four little mammæ at the apex, the bell-shaped butt, the slender groove, and the small faces.

Length, $4\frac{1}{2}$ inches; width, $2\frac{4}{10}$ inches.

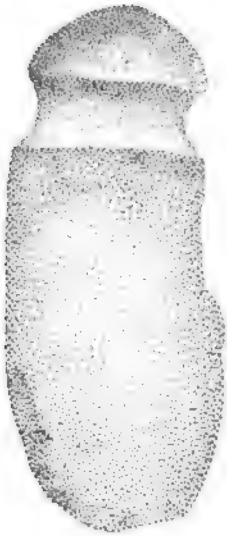


FIG. 113.

FIG. 114.

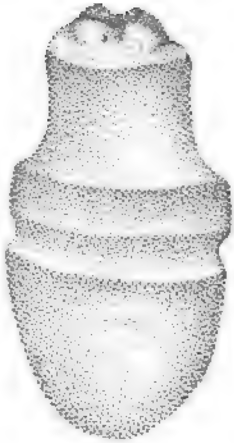


FIG. 115.

Fig. 116. A chopper-shaped blade of brick-red color. The butt and the face are boat-shaped, the former much smaller. The groove or neck is much thinner and cut away at both extremities. The sides are not symmetrical. (See Evan's figure, from Brazil, a war-ax of the Gaveoe Indians, in the British Museum, described in Ancient Stone Implements, figure 95. Compare also figure 96.)

Length, 3½ inches; width, 3½ inches.

FIG. 116.

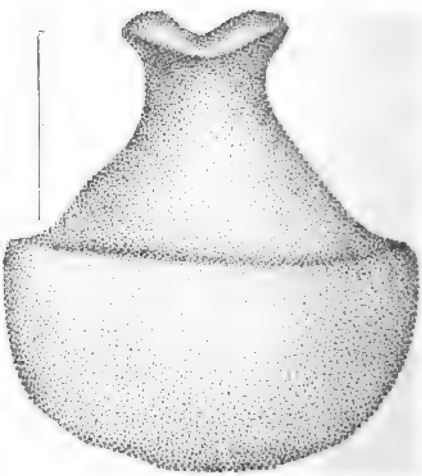


FIG. 117.

Fig. 117. A chopper-shaped blade of bright brown patina. There is in this specimen an interesting combination of characters. The butt has

a delicate double beak. The haft-space or neck widens rapidly, but is slightly shouldered all around its base. A similar butt and edge, with parallel sides, is to be seen in a specimen from St. Vincent, belonging to E. B. Griffith (*Timehri*, III, pl. vii, Fig. 3; and a very much ruder specimen in *Id.* I, 264, Fig. 1).

Length, 5 inches; width, 4 inches.

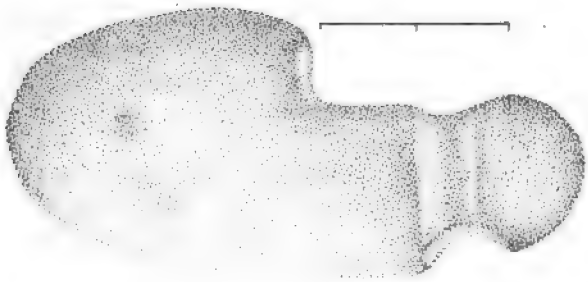


FIG. 118.

Fig. 118. A grooved blade of dark brown color and fine polish. The butt wedge-shaped and rounded. The hafting space is a complex affair, consisting of four parts, two narrow-faced grooves, a groove on the lower side a little wider, and a long, wide notch on the upper. The section of the groove is rectangular. The same idea of a shoulder on one side of the blade may be studied in a specimen from Mennithorpe, Yorkshire, England. This latter one, however, is very rude, and far behind the Guesde's example. (Evans' "Ancient Stone Implements," Fig. 82.) This blade lashed to a shouldered handle would be a very effective tool or weapon. From Marie-Golante.

Length, 6 inches; width, $2\frac{8}{10}$ inches.

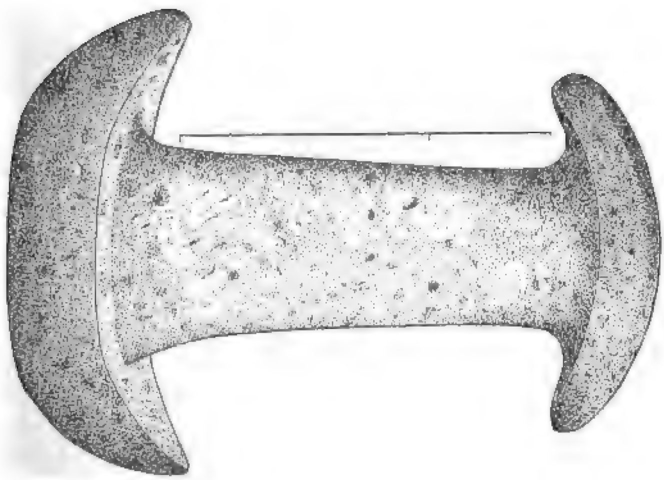


FIG. 119.

Fig. 119. A well-finished blade, of mottled-drab color. The central column is a flattened cylinder. The right portion is spread out like a smoothing tool. The Clallam Indians of Washington Territory, who excel in all kinds of basketry, use a little wooden implement exactly like this to smooth and regulate the woof in their grass and bark mats. The left end is canoe-shaped, and the edge extends to the extremities of the body.

Length, $5\frac{3}{10}$ inches; width of blade, $3\frac{8}{10}$ inches.

Fig. 120. A grooved implement of light brown color. It is introduced here to follow Fig. 119 on account of similarity in groove. The ax function is lost in that of the smoother or rubber. There is a great deal of nice work on this example; indeed, as a work of art it is nearly faultless. The furrows of the sides continued across the bottom of the shaft or neck below give a pleasing impression.

Length, $6\frac{7}{10}$ inches; width of lower blade, $4\frac{1}{2}$ inches.

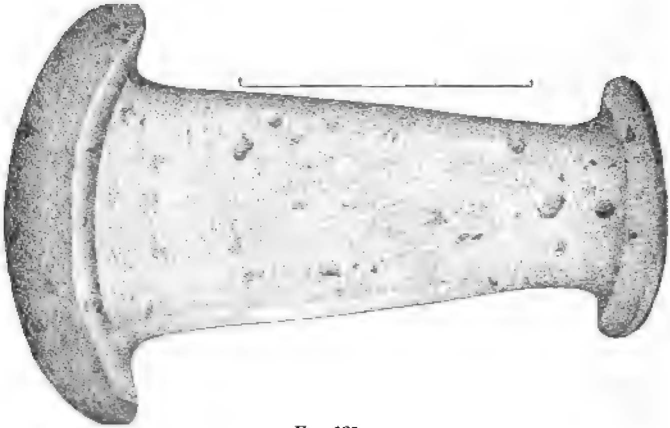


Fig. 120.

Fig. 121. A specimen of unknown function, light brown in color. This form wanders still further away from Fig. 119 than the last one described. The lower portion was formerly fluked, but the points are gone.

Length, 4 inches; greatest width, $2\frac{9}{10}$ inches.

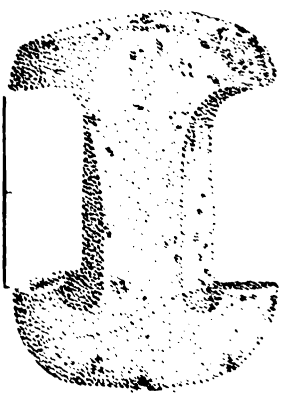


Fig. 121.

Fig. 122.

Fig. 122. A highly polished blade of seal brown color, resembling a chopper knife. It would be difficult to reconstruct the lost part, but it reminds one of the African and Brazilian battle-axes with crescent blades. (Compare *Timehri*, III, pl. 11.)

Length, $2\frac{8}{10}$ inches; width, $2\frac{9}{16}$ inches.

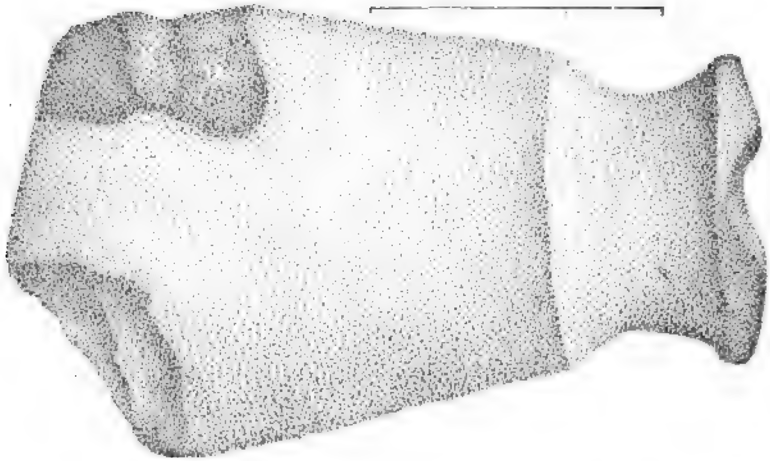


Fig. 123.

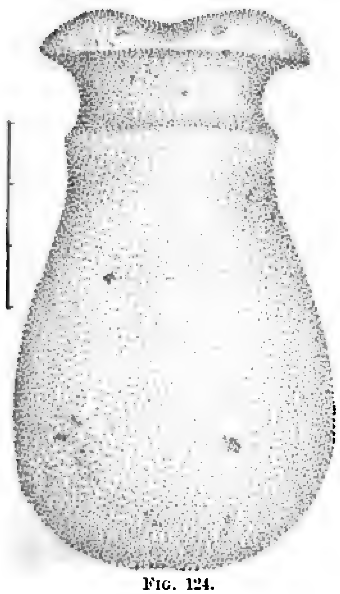


Fig. 124.

Fig. 125.

Fig. 123. A double-beaked blade of reddish brown surface and black interior. This and the following specimens should be compared with beaked specimens without grooves. There is a slight resemblance between this example and im Thurn's Plate 6, Fig. 1, at least in the long groove and the general outline of the blade.

Length, 8 inches; width, $4\frac{8}{10}$ inches.

Fig. 124. A double-beaked blade of bright drab color. The ridge beneath the groove gives to this example a very pleasing outline. Indeed, without excess of ornament, the whole contour is harmonized with great skill.

Length, 9 inches; width, $5\frac{2}{10}$ inches.

Fig. 125. A double-beaked massive blade of brown color. The curves beneath the beak and the fluting on the top are more elaborate than in the last one described.

Length, $11\frac{2}{10}$ inches; width, $5\frac{2}{10}$ inches.

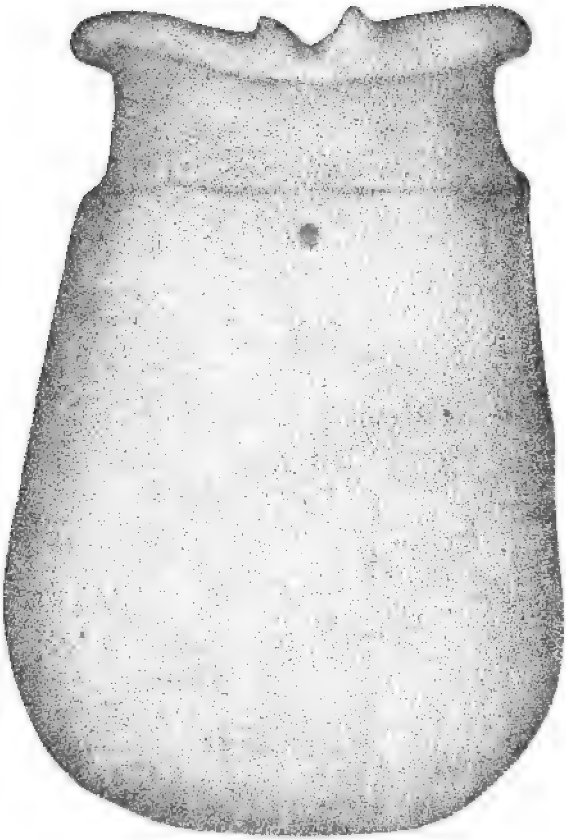


FIG. 126.

Fig. 126. A massive two-beaked blade of dark brown color, and so highly polished that it seems to have been recently made. The treat-

ment of the butt is a little different from that in the previous examples by reason of the width of the specimen. The upper ridge is narrow and the crests near the center.

Length, $8\frac{7}{10}$ inches; width, 6 inches.

Fig. 127. A two-beaked blade of dark brown color. The lower part is asymmetrical and fractured. The ornamentation left at the top indicates that originally it was a very beautiful object. The egg ornament occurs in other specimens.

Length, $7\frac{1}{2}$ inches; width, $3\frac{8}{10}$ inches.

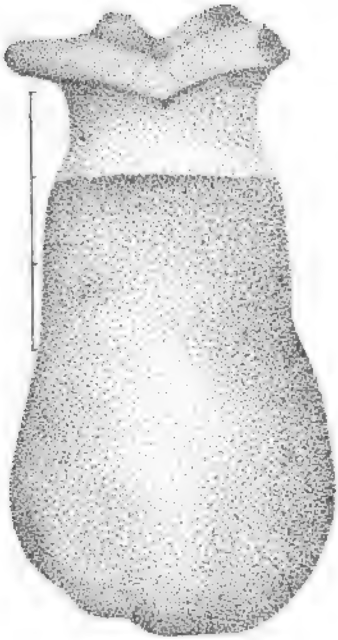


FIG. 127.

FIG. 128.

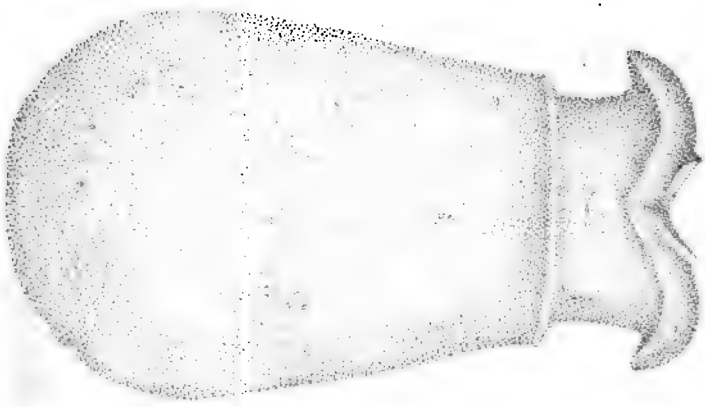


FIG. 129.

Fig. 128. A two-beaked blade of blackish-drab color, and perfectly smooth. The lines of this specimen are everywhere bold and graceful. The slender beaks, high crests, and other characteristics are very tastefully combined.

Length, $5\frac{8}{10}$ inches; width of edge, $2\frac{9}{10}$ inches.

Fig. 129. A massive two-beaked blade of mottled, marble-colored stone. The distinguishing feature is the ridged, seal-like depression between the beaks.

Length, $11\frac{3}{10}$ inches; width, $6\frac{4}{10}$ inches.

VII. HAMMERS, GRINDERS, AND POLISHERS.

In most archæological collections a series of implements are brought together under the titles given above. The idea or concept is that pounding, grinding, rolling or mulling-food, paint, incense, wedges, or human heads, are processes that have no broad dividing lines. Indeed, among a people so highly civilized as the ancient Antillians a great variety of such operations would be performed. Mr. im Thurn thinks that since these people were mainly cassava eaters they had little need of mills. True, but grinding is not confined to food even. The Haida and Thlinkit Indians make beautiful mortars and pestles to grind a native tobacco into snuff, and to pulverize dried fish. The Pueblos use grinders for corn and wild seeds, for paint, and to grind up degraissant for their pottery. The innumerable uses of hammers will occur to every one. The order followed in the description is almost arbitrary, the prevailing motive being to proceed from less to greater completeness.

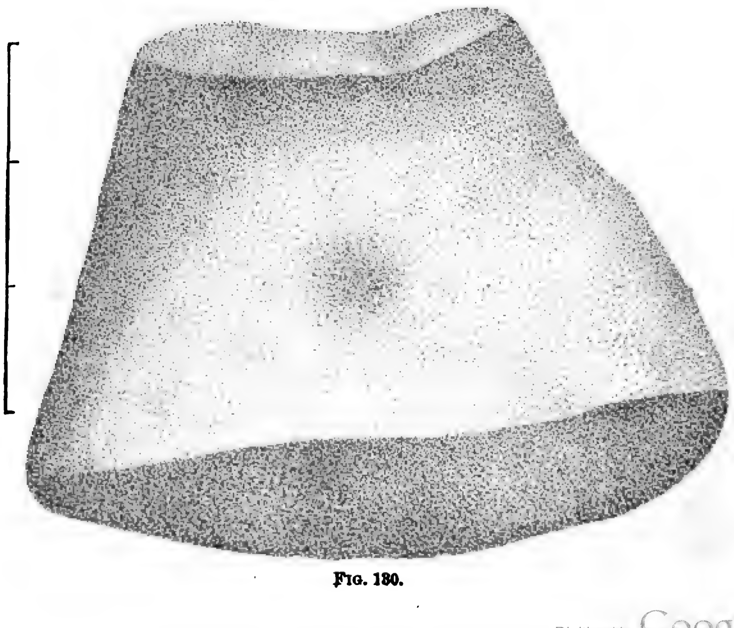


FIG. 130.

Fig. 130. At the risk of missing, a guess may be ventured that this specimen of dark brown stone is a hammer for wooden wedges. A great variety of wedge hammers of stone for splitting logs is used by the American Northwest Coast Indians. The finger pits on the faces should be noticed.

Height, $4\frac{2}{10}$ inches.

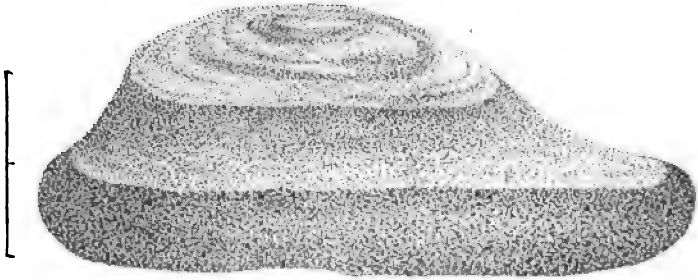


FIG. 131.

Fig. 131. A slightly modified water-worn pebble of dark brown color, just as likely as anything else to have been used in rubbing down pottery.

Length, $3\frac{1}{2}$ inches.

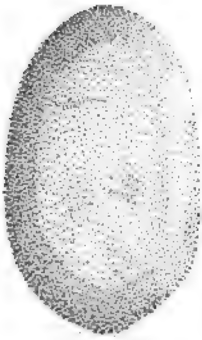


FIG. 132.

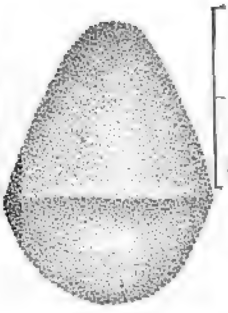


FIG. 133.

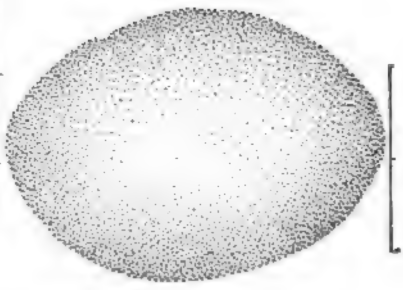


FIG. 134.

Fig. 132. An ellipsoidal form of blackish color. The noticeable features are the flat faces and beveled contour. In the Pueblo country such pebbles are used to rub down the pots before baking. From Gosier.

Length, $2\frac{7}{10}$ inches.

Fig. 133. A grinding stone of deep brown color, formed in the shape of a double conoid. The form is rare in the Antilles.

Height, $3\frac{1}{10}$ inches.

Fig. 134. A blackish stone, elliptical in outline and lenticular in section; highly polished.

Diameter, $4\frac{1}{10}$ inches.

FIG. 135.

Fig. 135. A shoe-shaped specimen of reddish brown patina resembling slightly the whetstones of the mounds.

Length, 6 inches.

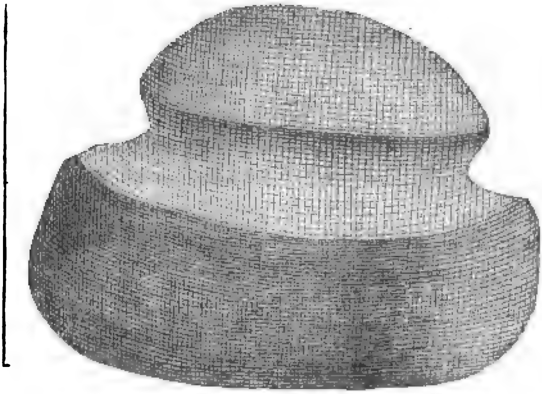


FIG. 136.

Fig. 136. A hammer-head of dark brown color, which would have done good service also as a mace or club head. The upper portion is convex, the groove uniform and the lower portion parallel sided.

Length, $2\frac{8}{10}$ inches.

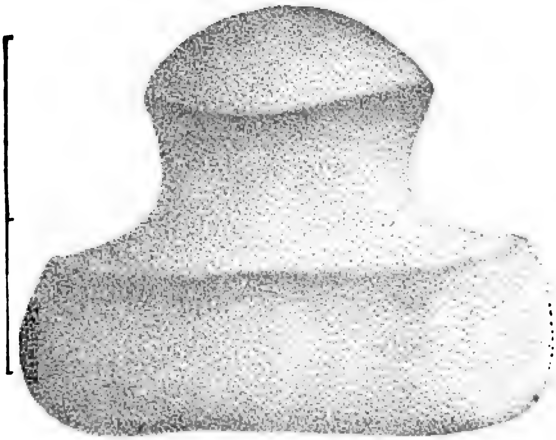


FIG. 137.

Fig. 137. A small hammer of light brown color. There are several implements of this class in M. Guesde's collection, which the owner considers casse-têtes. This may be, but they are just as probably hammers or rubbers.

Height, $2\frac{1}{10}$ inches.

FIG. 138.

FIG. 139.

Fig. 138. A grooved hammer resembling an old-fashioned printer's pad or an inverted mushroom. The function of the class is still in the dark. See Stevens "Flint Chips," p. 223.

Height, $3\frac{7}{10}$ inches.

Fig. 139. A grooved hammer of dark brown patina evidently made

FIG. 140.

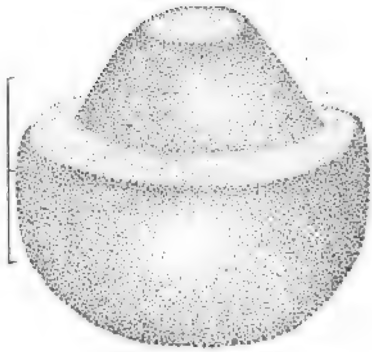


FIG. 141.

from a pebble with little modification. The groove is sinuous and shallow. In outline this specimen resembles an ax, but in M. Guesde's notes it is called a casse-tete.

Length, $2\frac{2}{10}$ inches.

Fig. 140. A grooved hammer resembling the last, but larger. The groove also is wider and has abrupt turns in direction.

Length, $2\frac{8}{10}$ inches.

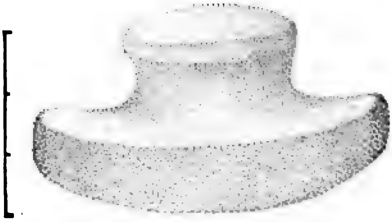


Fig. 142.

Fig. 141. A doubtful form of light brown color. The truncated cone resting on the bisecting plane of a hemisphere is absolutely unique.

Height, $3\frac{1}{2}$ inches.

Fig. 142. A finely polished specimen of chocolate brown color. The ornamentation is of a high order. It was probably a rubbing stone or muller.

Height, 3 inches.

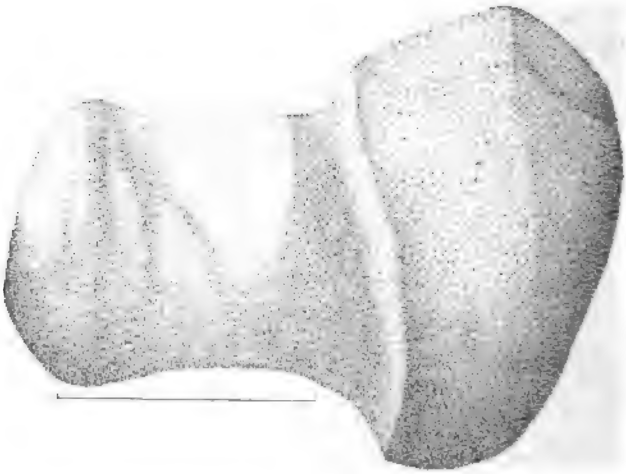


Fig. 143.

Fig. 143. A grooved hammer or pestle of brown color and very irregular in its details, the climax of asymmetry in fact. We are coming nearer to the typical hammers and triturators of the Northwest coast. Many as rude as this are found in the Ohio Valley.

Height, $4\frac{7}{10}$ inches.

Fig. 144. A grooved hammer or pestle of dark brown color. Mr. H. H. Hill, of Cincinnati, has a very large collection of slanting hammers or mullers taken from the mounds in that vicinity.

Length, $4\frac{1}{2}$ inches.

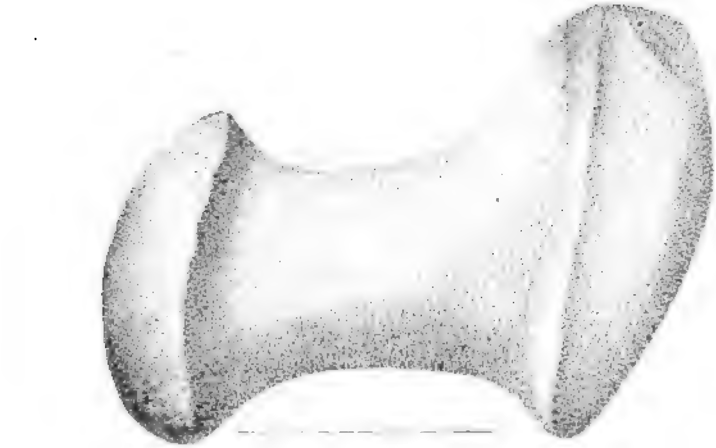


FIG. 144.

Fig. 145. A slanting grooved hammer or pestle similar to the last two. The function, however, is still in doubt.

Length, 4½ inches.

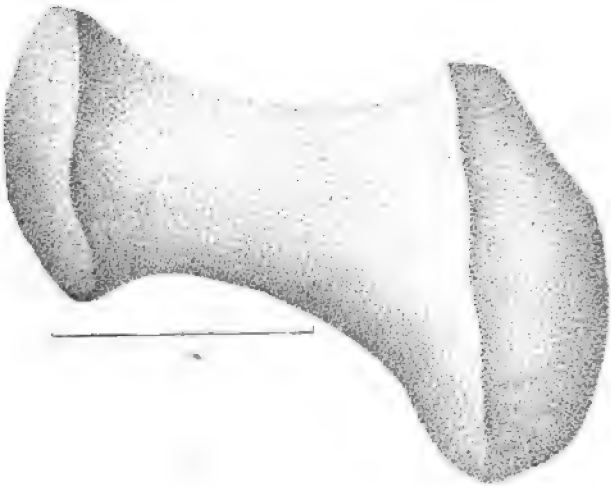


FIG. 145.

Fig. 146. A grooved hammer of light brown color. The implement was made and polished with great care, and the form is rare. Especially noteworthy are the truncated top, the uniform groove, and cylindrical sides. A similar implement from Antigua is figured in Timehri (III, p. 115, pl. 10, fig. 14).

Height, 5 inches.

Fig. 147. A grooved hammer or pestle of green and brown color. This long, pestle-like form is unique, in the Guesde collection.

Length, 4½ inches.

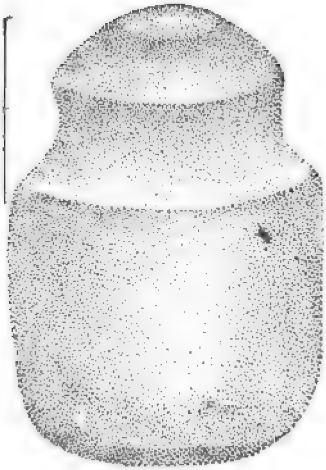


FIG. 146.

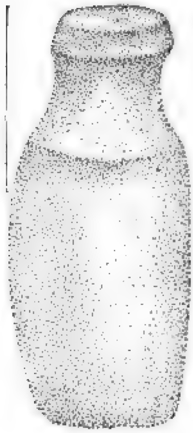


FIG. 147.

Fig. 148. A bell-shaped hammer of blackish color. The very large curved base is not unknown to hammers or pestles outside of the West Indies. Several of nearly the same shape may be seen from the Haida Indians in the National Museum. The offset on the rim below at the base of the neck is unique. (See *Timehri*, III, pl. 10, fig. 19.)

Height, 5½ inches.

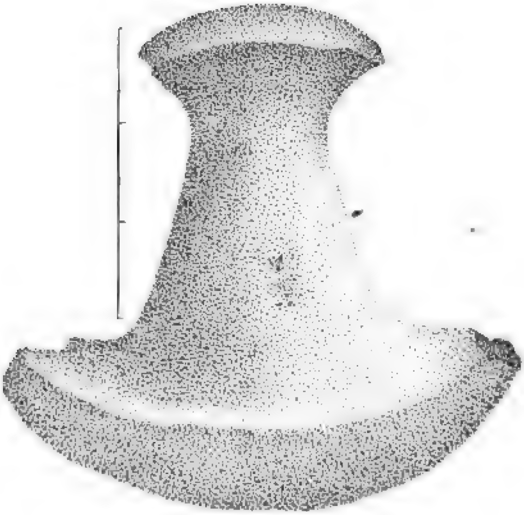


FIG. 148.

Fig. 149. Grooved hammer of brown color, and very highly polished. It is perfectly refreshing to stand once more on solid ground. Whatever

doubt may rest on the preceding examples, there is none here. The National Museum at Washington contains a large number of polished serpentine hammers of precisely this shape. The great red cedar abounds from Sitka along the Pacific Coast to California. The various tribes of this coast, Thlinkits, Haida, Chimsian, Bilhoula, formerly felled these trees with stone implements, and by means of a long line of hard-wood wedges split the logs into planks to be used in their houses and furniture. These wedges were skillfully driven by means of these serpentine hammers. The ancient Antillians felled large trees and both built houses and excavated dug-out boats. There is little doubt, therefore, that we have here the ancient carpenter's hand-maul.

Length, $3\frac{4}{10}$ inches.

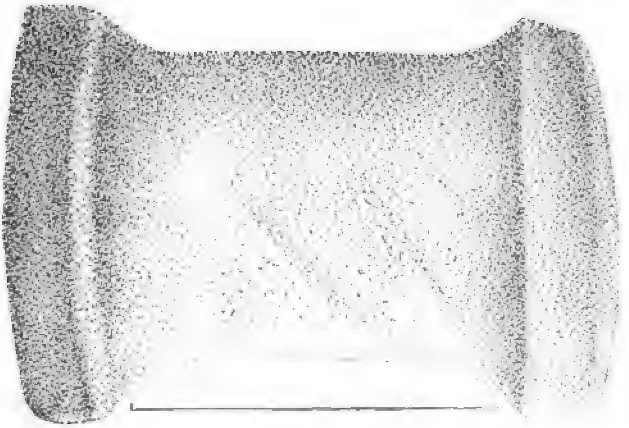


FIG. 149.

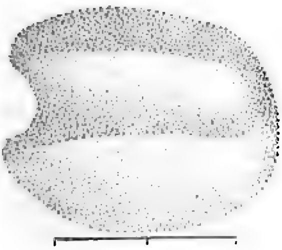


FIG. 150.

Fig. 150. A grooved club-head, widely excavated around three-fourths of its circumference. Stones wrapped with sinew or leather and lashed to a wooden handle were a common weapon with the ancient Dakotas.

Length $2\frac{3}{10}$ inches.

Figs. 151–154. Four grooved discoidal stones of unknown function. Comparing things unknown with things known we may declare these to have been club-heads or sinkers or playing stones or even ear-studs.

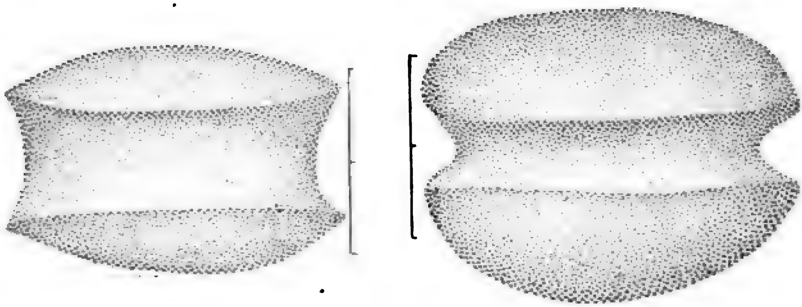
Fig. 155. A flat, grooved club-head shaped like a two-edged battle-ax. The groove is very sharp, or triangular in section, and is deeply cut in.

Length, $4\frac{3}{10}$ inches.

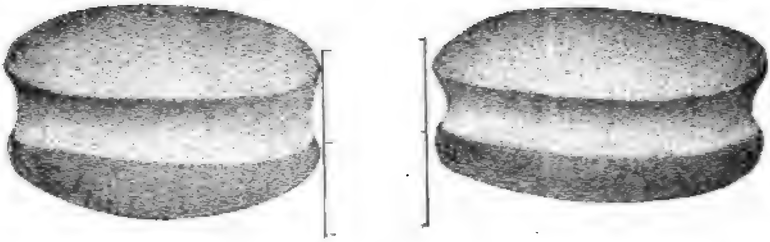
Fig. 156. A spindle-shaped implement, perhaps a rolling-pin, of brown color. In Yucatan the natives now use a roller of this shape, but of

different material. Some of the old metates have hollow beds, also indicating rollers, or mullers, thickened in the middle.

Length, $12\frac{3}{10}$ inches; width, $1\frac{2}{10}$ inches.



FIGS. 151, 152.



FIGS. 153, 154.

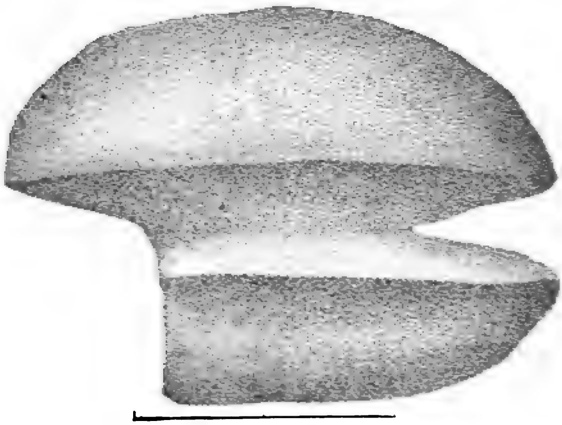


FIG. 155.

Fig. 157. A carved rubbing stone, of brown color. The slanting column and much-curved base, as well as the lateral flutings, extending everywhere except along the bottom, are noteworthy features. The

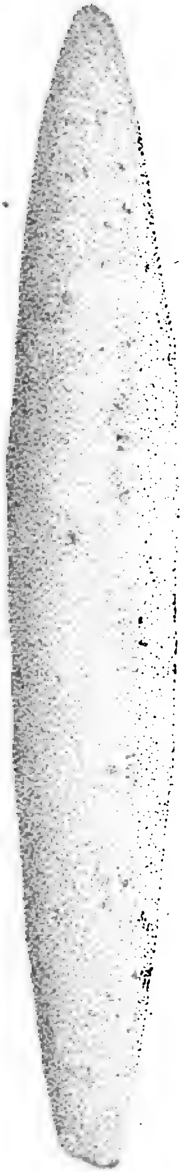


FIG. 156.

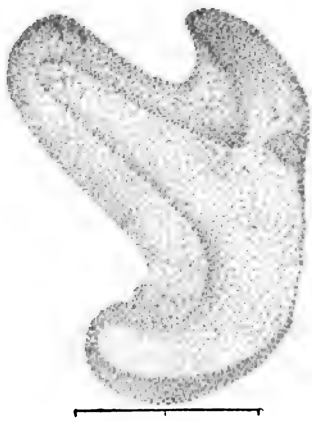


FIG. 157.

Eskimo of Norton Sound and northward excel in fashioning ivory scraper-handles to fit the artisan's hand. At Sitka the Thlinkit Indians also cut out the upper portion of the stone hand-maul to fit the hand.

Length, $4\frac{4}{16}$ inches.

Fig. 158. A boot-shaped rubbing stone, of dark brown color. The specimen resembles one in the Latimer collection of the National Museum; but this example is much heavier and more finely polished.

Length, 15½ inches.

FIG. 158.

Fig. 159. A carved and ornamented rubbing stone, of light brown color. Mr. im Thurn figures (*Timehri*, III, pl. 10, 11, 12) several forms. The specimen now under consideration is much more highly ornamented.

Height, $3\frac{2}{10}$ inches.

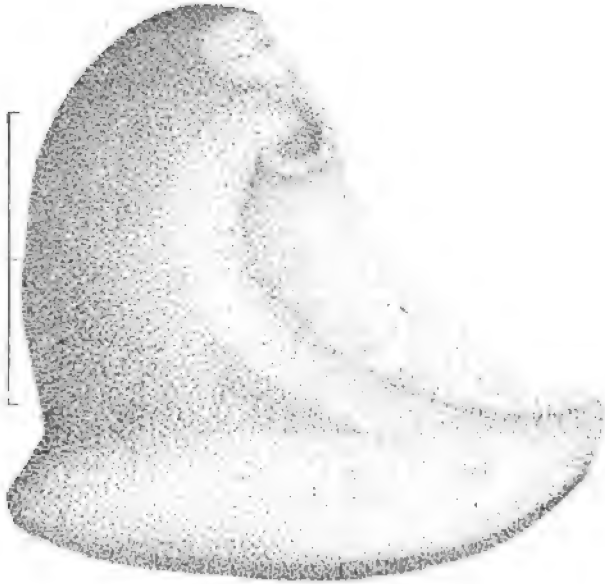


FIG. 159.

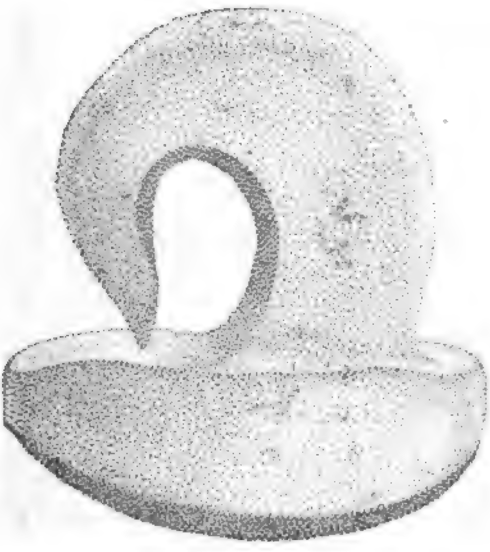


FIG. 160

Fig. 160. This object is entirely unique, and indeed outlandish to the Antilles. It is admirable in workmanship and has been preserved without a scratch. The material is mottled green and brown. It would not be difficult to guess, granting this to be genuine, that the process of stone carving went on after 1493, the year in which Columbus discovered Guadeloupe, and that some ingenious lapidary had undertaken to imitate a hook in the tackle. There is nothing improbable in this, for the Haida slate carvers, to-day, imitate steamers and other inventions of the whites in making their curious pipes.

Height, $5\frac{6}{10}$ inches.

Fig. 161. A rough mortar in the form of a California soapstone olla. Very little art has sufficed to bring this specimen to its present form. This is the only regular stone mortar as yet reported from the Antilles.

Height, $2\frac{6}{10}$ inches; diameter, 5 inches.

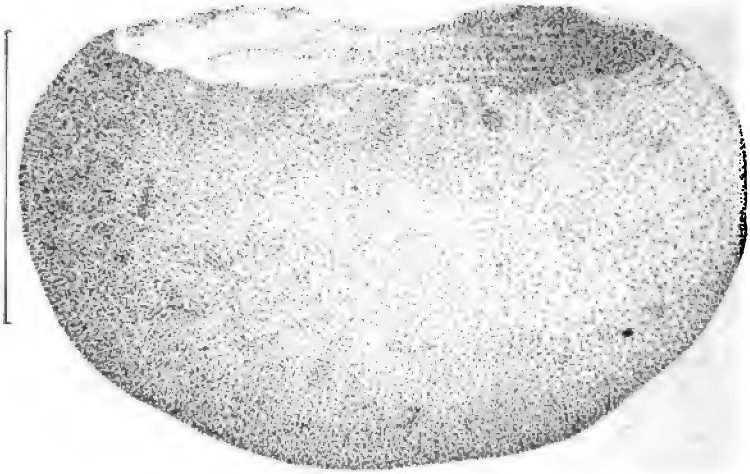


FIG. 161.

Fig. 162. A bowl-shaped mortar of rich brown color. This form also seems out of place in the West Indies. The almost perpendicular sides and regularly beveled edge carry the mind to the Queen Charlotte archipelago, where beautiful, small dish-like mortars were used for triturating the native tobacco.

Height, $2\frac{6}{10}$ inches; diameter, $6\frac{3}{10}$ inches.

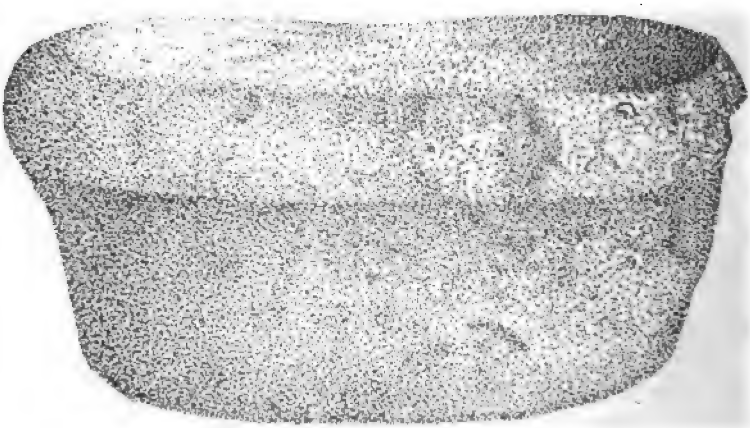


FIG. 162.

Fig. 163. A cylindrical stone dish, of dark brown patina, and very carefully made. Stone dishes quite as delicate come from Sitka, in which the ancient snuff-taker triturated his tobacco.

Width, $4\frac{9}{10}$ inches; depth, $2\frac{1}{2}$ inches.

Fig. 164. A cylindrical mortar and pestle of brown color. The mortar is cylindrical in form and a cup-shaped depression occupies the center. The pestle is of the dumb-bell pattern, very symmetrical in

FIG. 163.

form. This apparatus would serve much better as a snuff muller than for hard pounding.

Height of mortar, 4 inches; length of pestle, $4\frac{7}{10}$ inches.

Fig. 165. A stone hammer, of seal-brown patina. This style of implement is generally called a pestle. But no one has ever seen a savage wasting his time polishing a hard stone, and putting a shoulder around the bottom for the purpose of knocking it off the first time he used it. On the other hand, any one who will visit Vancouver Island may see such stones in use, to-day, for driving wedges into cedar logs to split them. It is reasonable, therefore, to call this specimen a hammer.

Length, $7\frac{4}{10}$ inches.

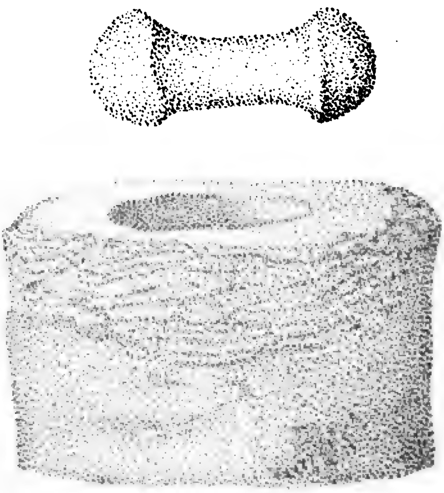


FIG. 164.

Fig. 166. A large grinding implement, of blackish surface, resembling a cook's rolling-pin. The central portion is convex on the upper side, and flat beneath. The club-shaped ends were evidently to be grasped in the hands. This is the rarest of forms.

FIG. 165.

From St. Anne.
Length, 14 inches.

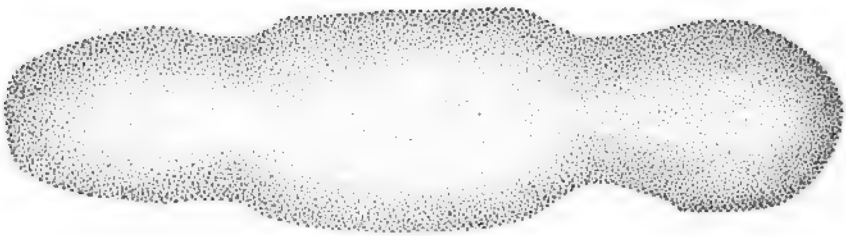


FIG. 166.

Fig. 167. A shallow, irregular mortar, of very dark brown color. Among North American relics this would be called a paint mortar. Fortunately the practices of our Pueblo Indians show us to what an enormous extent paint was used by the American aborigines. In Zuñi, for instance, the paint mortar never ceases. They are called into daily use by the potters, the warriors, and by the whole tribe, in the elaborate preparations for dances and ceremonies.

Height, $2\frac{1}{2}$ inches; diameter, $6\frac{4}{10}$ inches.

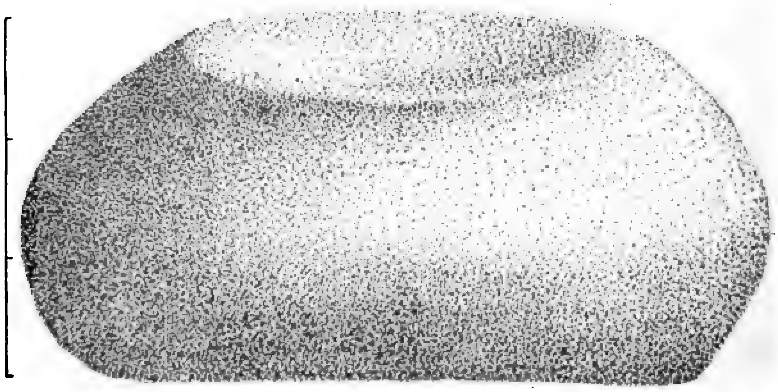


FIG. 167.

Fig. 168. A paint mortar, of brown color. It is provided with a handle partly broken. It is not an unusual thing among modern Indians to use paint mortars with handles.

Width, $3\frac{6}{10}$ inches.

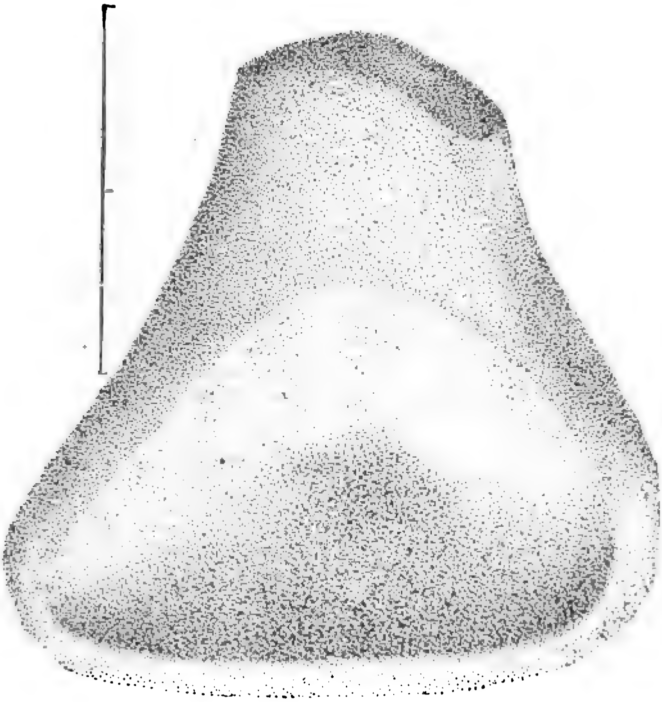


Fig. 168.

Fig. 169. A pretty dish of rich brown color. It is oval outline, and perfectly polished inside and out. The two ends are not quite symmetrical.

Diameter, $5\frac{1}{2}$ inches.

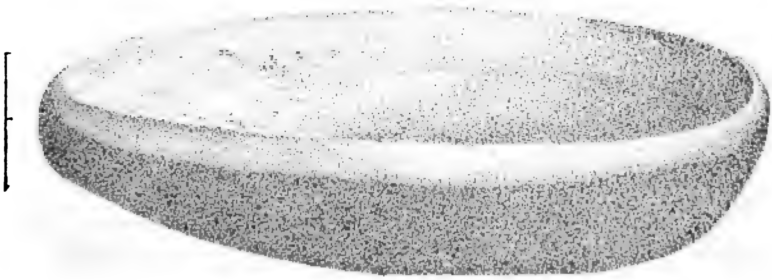


Fig. 169.

Fig. 170. A double concave disk of dark brown color, very smooth and beautifully rounded. Archæologists sometimes call such beautiful objects paint-mortars and sometimes chungke stones. The Navajos,

says Dr. Washington Matthews, at the present day play with the intensest excitement a game called "turkey claw." Two players contend in the following manner: Each one is provided with a pole, twice a man's span in length, consisting of two parts lashed together by a long leather thong, either end of which hangs loose for about a yard. At distances of nearly a foot on these loose ends are sewed crosswise similar leather thongs so that there seems to be two tassels of five strands each. At a given signal a ring, made by wrapping rawhide strings around a hoop, until it becomes very thick and heavy, is rolled along the ground. The players aim to throw their spears so that the ring in falling will gather up and become entangled with several of the leather strands. The number and position of strands lying on the ring enables the players to decide the game. There is no reason why such a disk should not be thus used. The statement made by writers that the pole should pierce the ring is not strictly true.

Diameter, $5\frac{2}{10}$ inches.

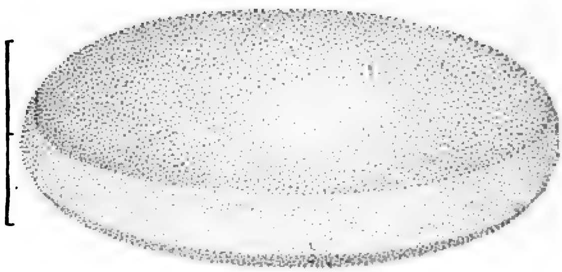


FIG. 170.

Fig. 171. A very highly polished implement of dark brown color, and presenting one of those enigmatic forms that are ever springing upon us in the West Indian area. The general outline is that of a ladle. Upon the reverse the face is flat, but the broad portion of the obverse is slightly concave and bordered by a molding which is carried nearly to the narrow portion. The latter is lingulate in form and has ten concentric ridges terminating in the border which is fluted externally. There is no duplicate of this form.

Length, $12\frac{1}{4}$ inches.

Fig. 172. An unique specimen of light-brown color and quite rough. It is hollow like a mortar, but the most remarkable feature about it is the series of flutings on the surface. M. Guesde is of the opinion that it was rather a cover for something than a grinding stone. In deference to this opinion it is drawn with the broad part downward.

Height, $6\frac{1}{2}$ inches.

Fig. 173. A smooth mortar of very dark color. The figure of a flying creature is well executed and beautifully polished. The cavity is also made with great care. It would not be wild speculation to imag-

FIG. 171.

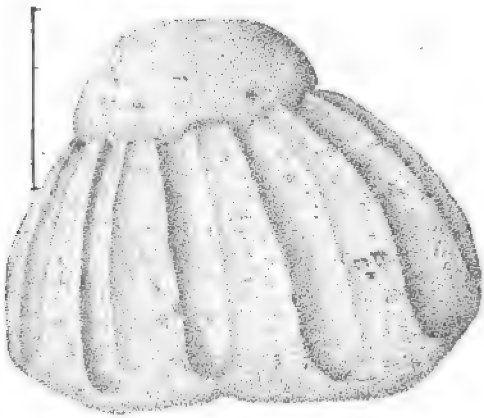


FIG. 172.

ine this the cosmetic mortar of some proud cacique long before the days of Guanecagaro. (From Porto Rico.)

Length, $8\frac{4}{10}$ inches; width 9 inches.

VIII. PERFORATED STONES.

The perforation of stone by the American aborigines has been faithfully studied by Dr. Charles Rau and others. When the boring is for a short distance two conical excavations are made from opposite sides, making a cavity shaped like an hour-glass. The process of boring a similar hole is commonly called countersinking. The West Indians as well as other aborigines of our continent also understood how to produce long excavations through very hard material, but never with the uniformity of a steel drill. One of the best tests of genuine relics of this class is the method of perforation.

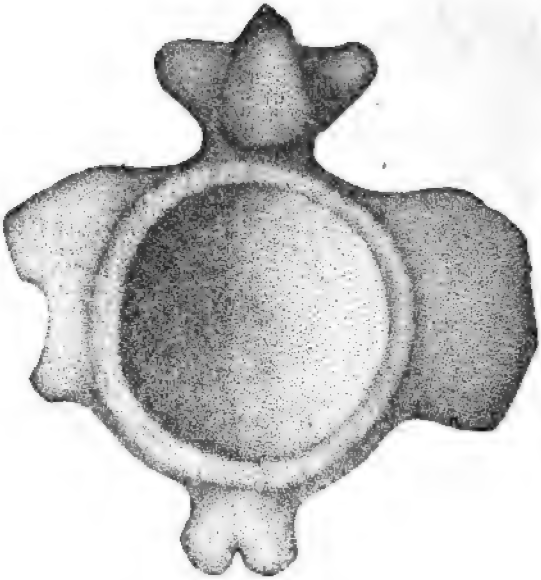


FIG. 173.

Figs. 174–178. Ordinary pebbles with a double countersink perforation near the border, generally so located that the long axis will be vertical. These are beautifully polished, and there is little doubt that they were worn as pendants.

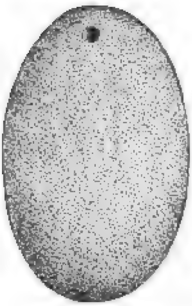


FIG. 174.

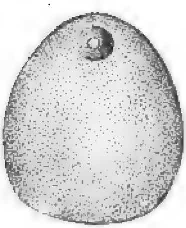


FIG. 175.

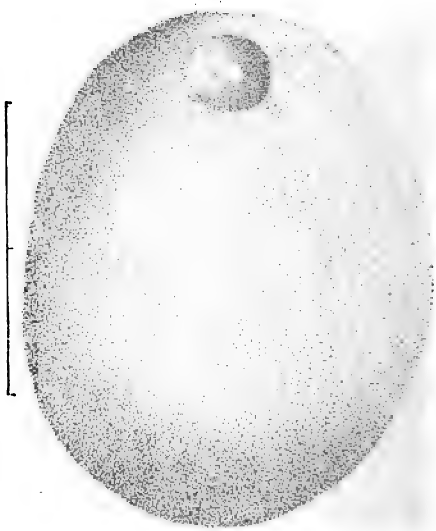
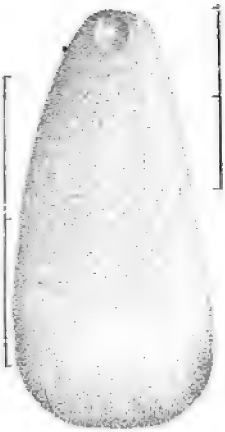


FIG. 176.

Long diameter of 174, $1\frac{6}{10}$ inches.
Long diameter of 175, $1\frac{1}{10}$ inches.
Long diameter of 176, $3\frac{1}{2}$ inches.



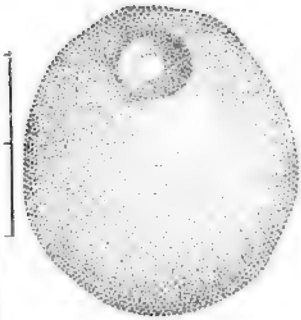


FIG. 179.

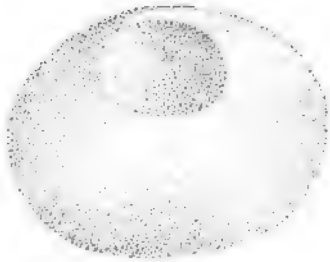


FIG. 180.

FIG. 177.

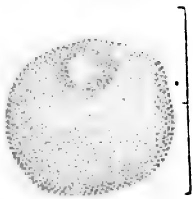


FIG. 178.

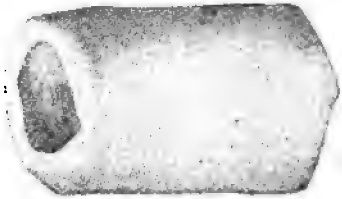


FIG. 181.

Long diameter of 177, $2\frac{8}{10}$ inches.
Long diameter of 178, $1\frac{7}{10}$ inches.
Long diameter of 179, $1\frac{7}{10}$ inches.
Long diameter of 180, $1\frac{4}{10}$ inches.

181. A perforated cylinder, of drab color, beautifully polished. This is a larger bore than is usual in West Indian specimens. The ancient lapidaries of this area excelled in the fineness of their perforations.

Length, $1\frac{4}{10}$ inches.

182. A stone ring, ovoid in outline, pierced by a double countersink in the middle. Stones of the same treatment are found in Porto Rico too heavy for a man to lift, which are undoubtedly unfinished collars. Length, 3 inches.

FIG. 182.

Fig. 183. A stone ring of great asymmetry. This perforation was probably made by pecking, its faces being rubbed down afterwards.

Dimensions, $5\frac{2}{10} \times 4\frac{7}{10}$ inches.

Fig. 184. A stone ring of still greater finish. Were it not for the material one might suppose M. Guesde had collected the specimen on the Santa Barbara Islands, in California. These rings have caused considerable guessing among archæologists, who call them whorls, digging-stick weights, casse-têtes, etc.

Diameter, $4\frac{8}{10}$ inches.

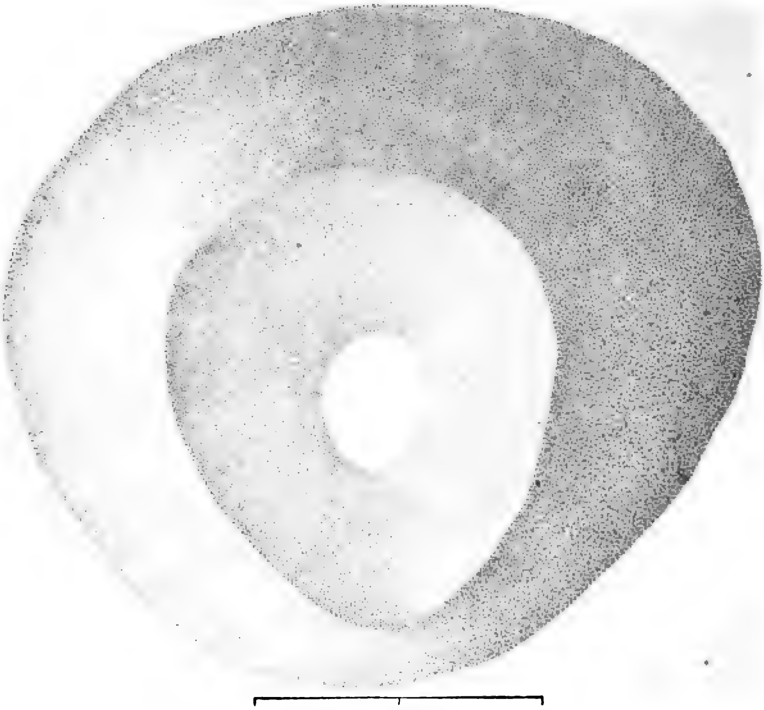


FIG. 183.

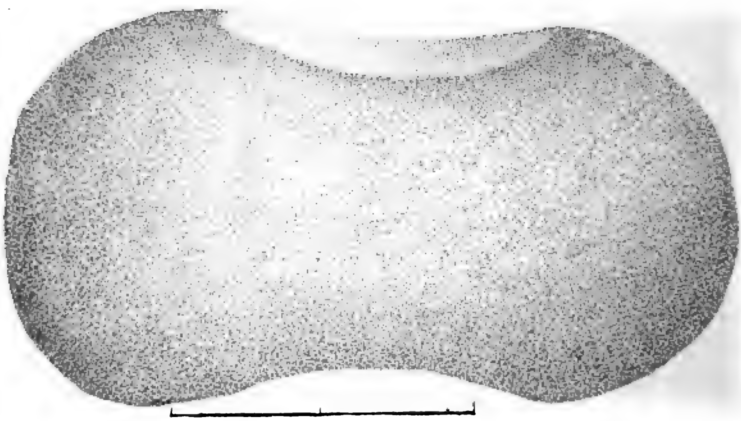


FIG. 184.

Fig. 185, 1 and 2. A beautifully finished stone pulley. The points to be noticed are the nearly circular outline, the countersink perforation, the curved slope of the sides, and the groove in the circumference. This last feature is unknown to the author of these notes in any other stone implement. The edge view is enlarged to exhibit the groove.

Diameter, $1\frac{8}{10}$ inches.

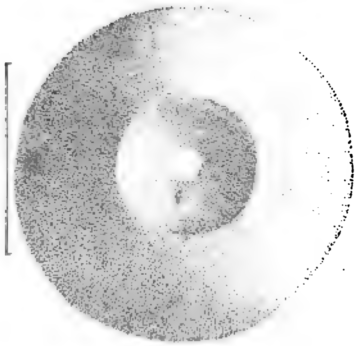


FIG. 185.—1.

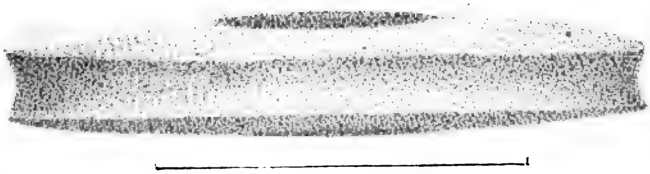


FIG. 185.—2.

Fig. 186. A spool-shaped object, highly polished. The excavation does not pierce the stone. As the natives of this area distended their ears to a great extent, we may be allowed to call this an ear-plug.

Height, $1\frac{1}{2}$ inches.

IX. ORNAMENTAL FORMS.

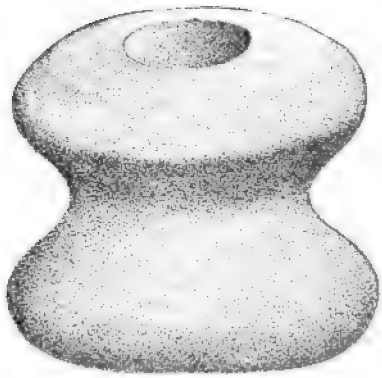


FIG. 186.

In this group have been brought together those specimens in which ornament is of more importance than use. They are not all made of stone, and a few of them are not in M. Guesde's collection. The last named have come into the National Museum since the description of the Latimer collection in 1876. (Smithsonian Report, 1876, p. 372–393.) It is not to be supposed that the makers designed any such division of their artefacts.

Fig. 187, 1 and 2. A beautifully polished object, and symmetrically formed in face and profile, the outlines of the edge view making a very pleasant combination.

Length, $3\frac{4}{10}$ inches.

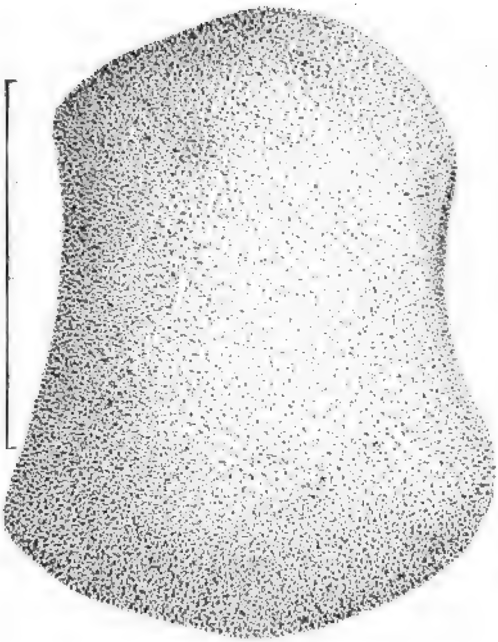


FIG. 187–1.

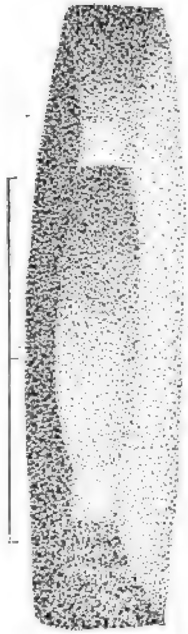


FIG. 187–2.

Fig. 188, 1 and 2. A similar object to that last described but not nearly so well formed.

Length, $3\frac{1}{10}$ inches.

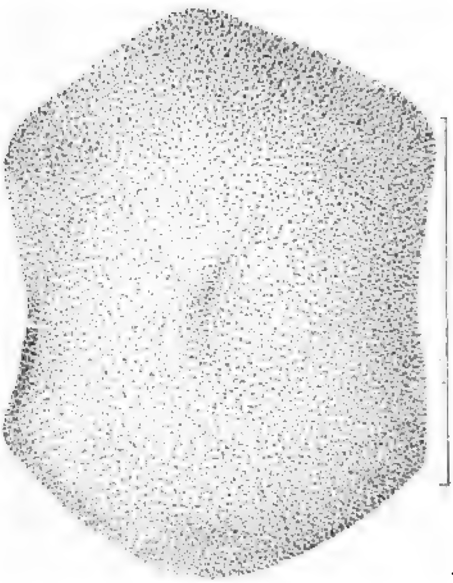


FIG. 188–1.

FIG. 188–2.

Fig. 189. A pick-shaped object, one projection broken. The surface is beautifully polished.

Length, 7 inches.

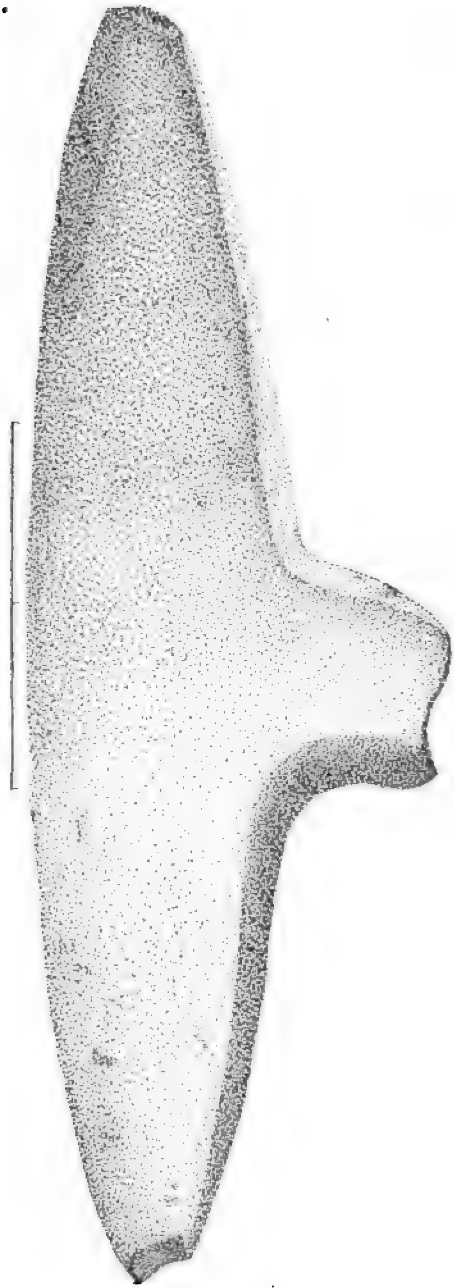


FIG. 189.

Fig. 190. A curved object of light brown color. If the lapidary designed to produce the outline of a banana he succeeded admirably.

Length, 6 inches; width, $1\frac{1}{2}$ inches.

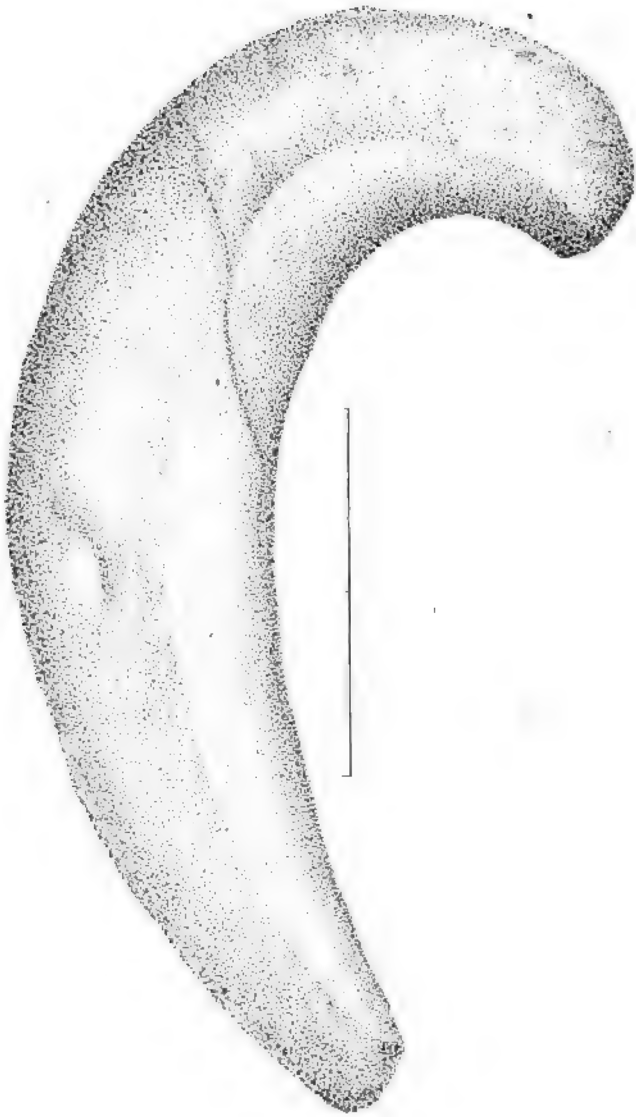


Fig. 190.

Fig. 191. A hook-shaped stone, very similar in finish to the last. From Canoe.

Length, 8 inches.

FIG. 191.

Fig. 192. A V shaped object of light brown color. It is possibly an amulet worn suspended from the neck. This should be compared with an ornament called by the Caribs, Caracoli, or Coulloucoli, and made of a metal resembling gold, obtained from the Alloüagues, of South America.

Width of limb, $4\frac{2}{10}$ inches.

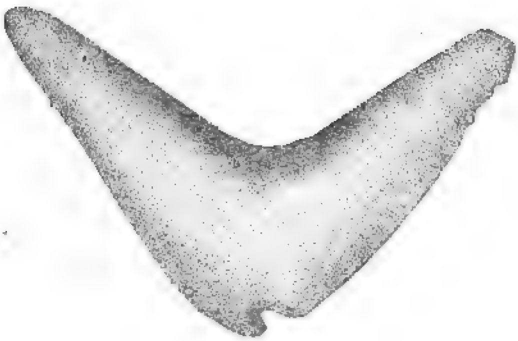


FIG. 192.

Fig. 193. The object sketched in this figure resembles some of the plainest specimens of mammiform stones from Porto Rico, in the Latimer collection. (Smithonian Report, 1876.) No head or legs are indicated in the projections from the base. The lower face, not seen in the drawing, is concave and there is a hole in the apex. On either face of the mamma are distinct ridges. Mr. im Thurn figures one of these objects and calls attention to examples from San Domingo in Blackmore Museum. His own specimen is described as having animal heads at either end. This does not correspond with the one in the Latimer series, in each of which there is a head at one end and feet at the other. Their use as stools is very questionable, because that would bring the unsightly portion upward and bury the ornamental portion out of sight. The owner of the small island of Canouan, says Mr. Low, has a mammiform resembling Fig. 42, Latimer collection, with carved lines like those on Fig. 43. (See also *Timehri*, I, 268, 269.)

Length, $11\frac{1}{2}$ inches; height, 7 inches.

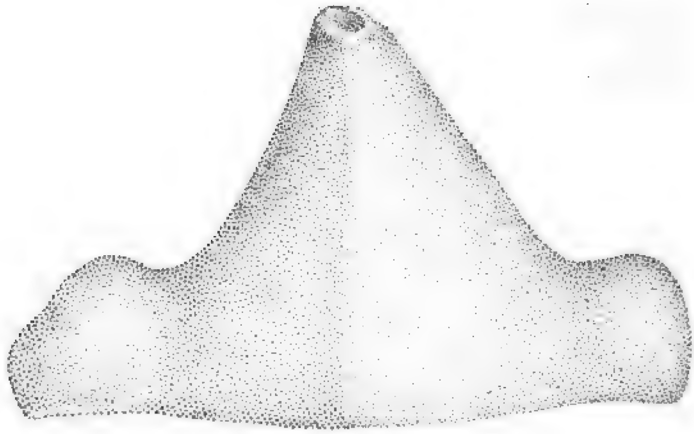


FIG. 193.

Fig. 194. This object is absolutely unique, for we have in it a miniature fire-place or altar, both faces of which are identical. Four rude steplets conduct to a landing place partly covered by a niche. At the top an excavation is seen which may have served for a statuette. The object was found at Abymes, but the evidence of aboriginal origin should be strong just in comparison to the outlandishness of a specimen.

Height, 6 inches.

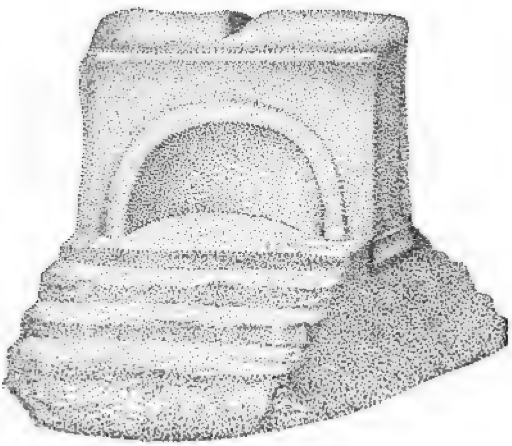


FIG. 194.

Fig. 195. An ornamental piece, of bluish green color. It is rare in form, but not absolutely unique. In the American Museum at New York is a similar specimen. The chamfering and fluting are gracefully blended. The left-hand extremity is perforated for suspension. From Punto Duo.

Length of long limb, 8 inches; of short limb, $5\frac{3}{10}$ inches.

Fig. 196. A highly ornamented specimen, one portion of which is plain, resembling the edge of a cleaver; the remainder is covered with ornament. Let us imagine this to be a stone ax, the most beautiful in the world. The following characteristics claim our attention: The hafting notches are extended, that on the upper part by a narrow gutter almost parallel with the edge; that on the lower part sweeping outward in a curve which combines

FIG. 195.

the lower portion and both faces in a continuous pattern. This is assuredly M. Guesde's jewel in the ax class.

Length, 5½ inches.

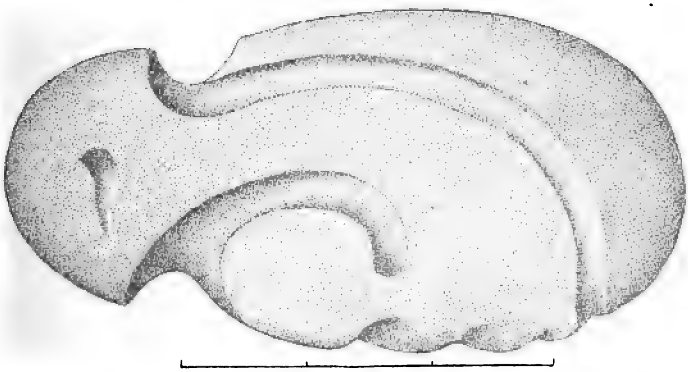


FIG. 196.

Fig. 197. An ornamental stone of a marble gray color. The right part is conoidal and has near its middle a raised band. This may have fitted a socket. The left part resembles a liberty cap, bounded at its base by the curve of beauty. On the two sides of the enlarged middle are compound scrolls in relief, resembling the implements sold to draughtsmen for making curves.

Length, 11½ inches.

Fig. 198. A stone collar of very dark brown patina. This belongs to that class of enigmatical objects which formed such an attractive feature in the Latimer collection from Porto Rico. (Smithsonian Report, 1876, 372–393.) It is of the left-shouldered variety; that is, imagining the object suspended from the neck like a regalia, there is a projection on

FIG. 197

FIG. 198.

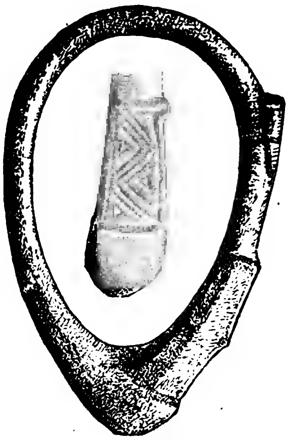


FIG. 199.

the left side faintly resembling a lashing of the two ends of a hoop. This being on the left, the ornamental panel is on the right. The elements of this panel are not unique. Notice first the beading looped on the right side at the top of the panel, and widening downward to inclose the key ornaments and to pass quite around the boss below. The border on the edge outside and in front of this bead has a human face between two opposing scrolls. The bas-relief ornament inside the bead consists of a double ring in relief, with two ornaments as nearly alike as the varying space would admit.

Length, $17\frac{2}{10}$ inches; thickness of side, $1\frac{6}{10}$ inches. (Compare table in Smithsonian Report, 1876, p. 390.)

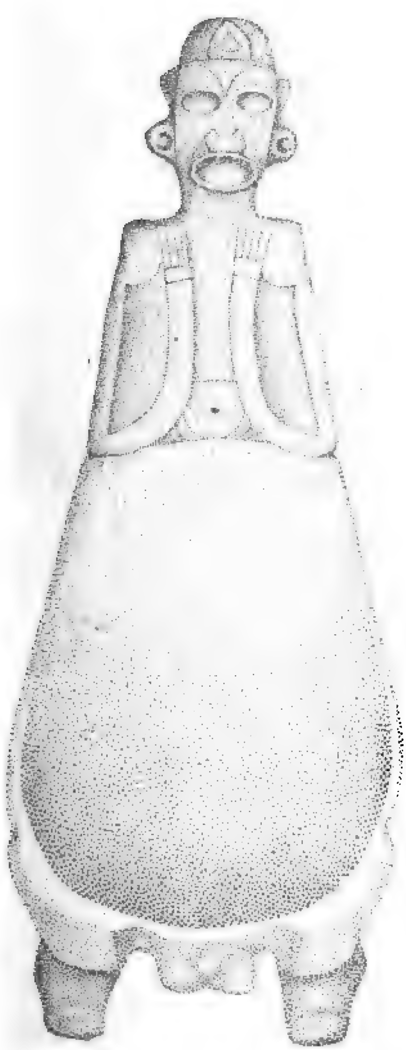


FIG. 200.

Fig. 199. A collar from San Domingo, probably obtained in Porto Rico. It does not belong to M. Guesde's collection, but the figure will explain some features omitted in the last. This is also left-shouldered. The shoulder projection, the looped bead, with its herring-bone ridges, inclosing triangular excavations, the boss, and the slight ornament on the shouldered side are all well expressed. Although both these are left-shouldered, there are many right-shouldered ones, plainly showing that they were to be used in pairs.

Fig. 200. A stone stool or chair of the variety mentioned and illustrated in the Smithsonian Report, 1876, p. 376. The material of those there described, however, is either sandstone or wood, and the device is some animal form. In M. Guesde's specimen the material is a dark brown volcanic stone, and the device is the human form. Moreover, the position is inverted. The man is lying on his back, with his feet drawn up to form the legs of the stool. His arms, without any attempt at accuracy of delineation are doubled on his neck. The eyes and mouth are like the same features in all aboriginal statuary, and beautiful shells were doubtless inserted in them. The ears have large openings in which were in-

serted plugs of wood, stone, shell, or feathers. The legs of the chair, just beneath the man's shoulders, are mere projections from the stone. The markings in the head and forehead are quite tastefully designed. The back does not slope upward as much as in the Latimer specimens. In Dr. Liborio Lerda's "Eldorado" is figured a mummified human body seated on a stone stool in a cist. The figure in this paper and notes of im Thurn (*Timehri*, I, 271) should be consulted. The impossibility of using such objects as mealing stones was pointed out by the author of these notes ten years ago, and im Thurn adds the very pertinent argument that the ancient West Indians did not grind maize, subsisting mainly on cassava. Dr. Joseph Jones quotes Sheldon as saying, "When a Carib died his body was placed in the grave in an attitude resembling that in which they crouched around the fire or the table when alive, with the elbows on the knees and the palms of the hands against the cheeks."

Length, 16 inches; width, 6½ inches; height of head, 6½ inches; of feet, 2 to 3 inches.

Figs. 201–202. A low wooden stool from Turk's Island, collected by the late W. M. Gabb. This form is similar to those described in a previous publication, and referred to by the historians of Columbus. The ornamentation of the countenance of the human head are best shown in Fig. 202 *a*. The labyrinthine design of the seat ornament, the scrolls, lozenges, and chevrons in the head ornaments are most praiseworthy. Length, 46 inches. (202*a*, *b*, *c*, *d*.)

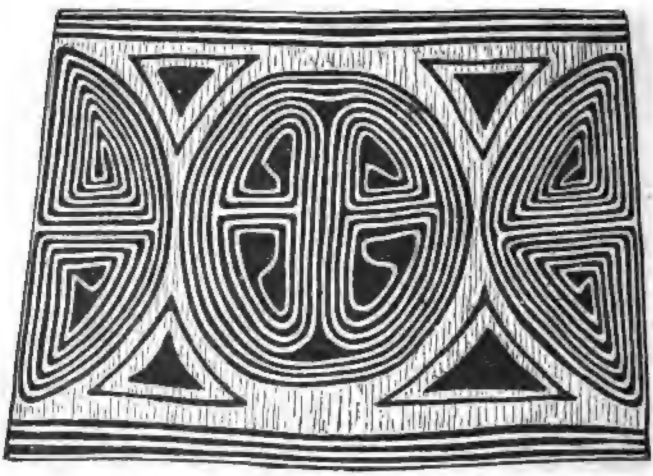


FIG. 202 *d*.

Fig. 203. A human figure carved from a single log of wood. The portions broken away render it impossible to tell how large the image was originally and what position the figure occupied. Especially notice-

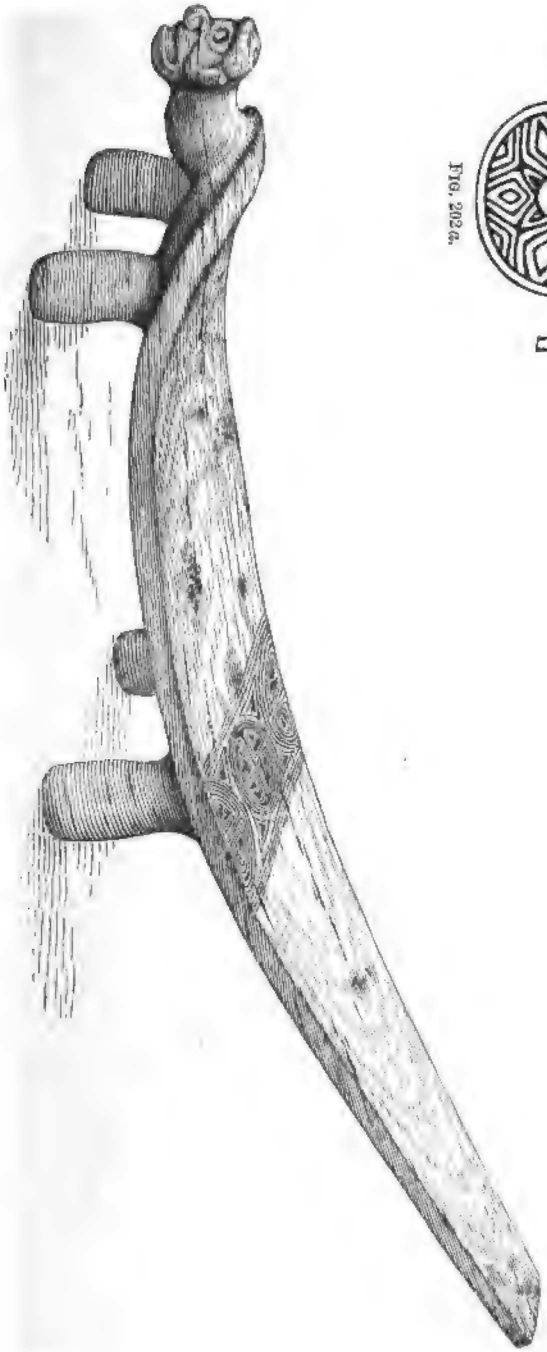


FIG. 201

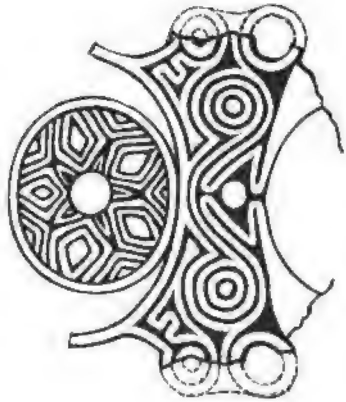


FIG. 202a.

FIG. 202b.

FIG. 202c

able are the ear-plugs and the bands drawn tightly around the muscle of the arms. This feature is explained in the next figure. Length, 43 inches.

FIG. 203.

Figs. 204, 205. This carving represents two individuals seated on a canopied chair. The whole thing is interesting to the highest degree. The chair has a high back ornamented with scrolls and concentric rings. Both individuals have embroidered skull caps, the nearest approach to which are the basket work, close-fitting embroidered hats of the Indians of the Great Interior Basin of the United States. The ears much distended are to be looked for. The most noteworthy feature, however, is the bands of embroidered cotton just above the calves. In his second voyage, cruising among the Caribbee Islands, Columbus came on the 10th of November, 1493, to Santa Cruz Island. Here he had a fight with some natives in a dug-out and wounded some of them. "The hair of these savages was long and coarse, their eyes were encircled with

Fig. 204.

paint so as to give them a hideous expression; and bands of cotton were bound firmly above and below the muscular part of the arms and legs so as to cause them to swell to a disproportioned size." (Irving's Columbus, I, 333.) Height, 31 inches.

FIG. 205.

Figs. 206, 207. Spoon and cup carved from the guava fruit. The spoon and mug are both of European form, but it would be exceedingly interesting to obtain some of the ancient forms. It is more than probable that the gourd and jicara fruit and cocoa played an important part in this portion of the economy of the ancient Caribs.

Fig. 208. In this figure is represented an inscribed slab found in a portion of Guadeloupe, properly so called. It weighs several tons and

FIG. 206.

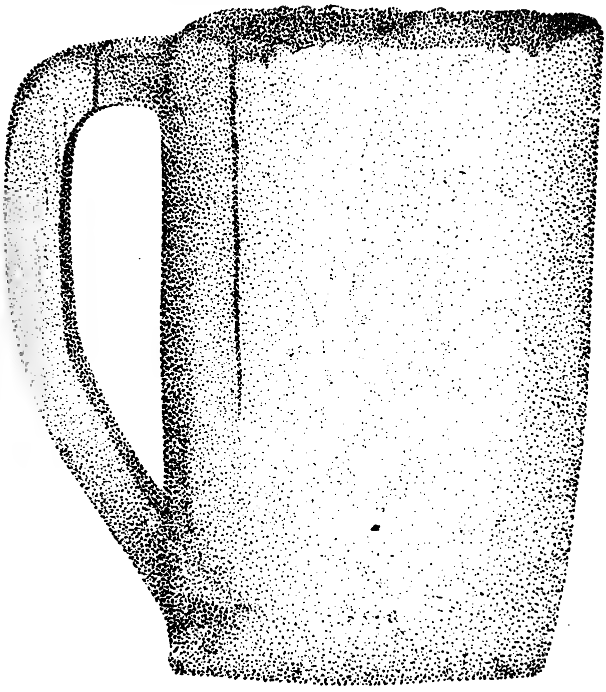


FIG. 207.

it is impossible to remove it. In the vicinity are to be seen many other rocks bearing inscriptions, but this is the most elaborate of the group. The general appearance of the figures is not dissimilar to those on the cover of the journal published in Demerara, called *Timehri*, 208, a.

FIG. 208.

FIG. 208 *a*.

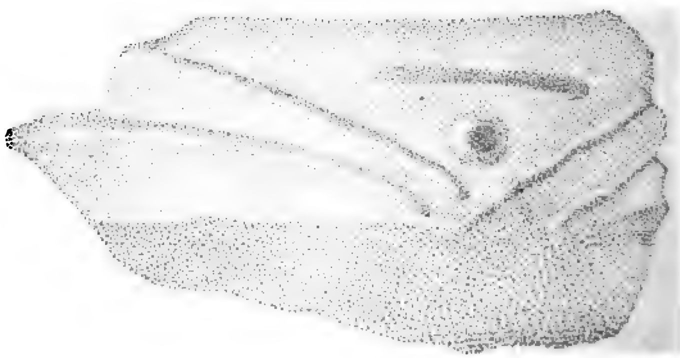


FIG. 209.

Figs. 209–213. Specimens of pottery in M. Guesde's collection. They do not differ at all from those found throughout the West Indies. The material is poorly worked but well baked and most of the designs on the handles are boldly conceived. (See also *Timehri*, III, pl. 14–17.)

FIG. 210 *a*.

FIG. 210 *b*.

FIG. 210 *c*.

FIG. 211.

FIG. 212.

Fig. 214. This is the best preserved fragment of pottery as yet figured from this area. The cylindrical mouth and the ornamental body point to a vessel of some pretensions. It is impossible to conjecture what was the continuation of the lower portion.

FIG. 213.

FIG. 214.

Figures 215, 215 *a*. In the introduction to this paper M. Guesde speaks of shell celts; they are also mentioned over and over again in Stevens' "Flint Chips," and those familiar with the arts of Polynesia will recall the beautiful adze blades scarcely distinguishable from chalcedony, keeping clearly in mind the fact that the people of each area utilize always the best materials and processes consistent with their

grade of civilization. The whole subject of art in shell is exhaustively treated by W. H. Holmes in Second Annual Report of the Bureau of Ethnology, pp. 203–205. (See also *Timehri*, III, pl. 13.)

FIG. 215.

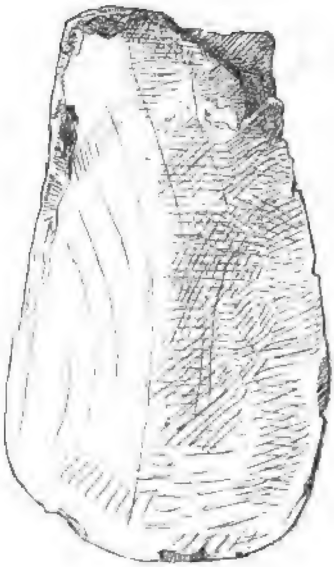


FIG. 215 *a*.

PAPERS RELATING TO ANTHROPOLOGY.

ANCIENT MOUNDS IN CLINTON COUNTY, MICHIGAN.

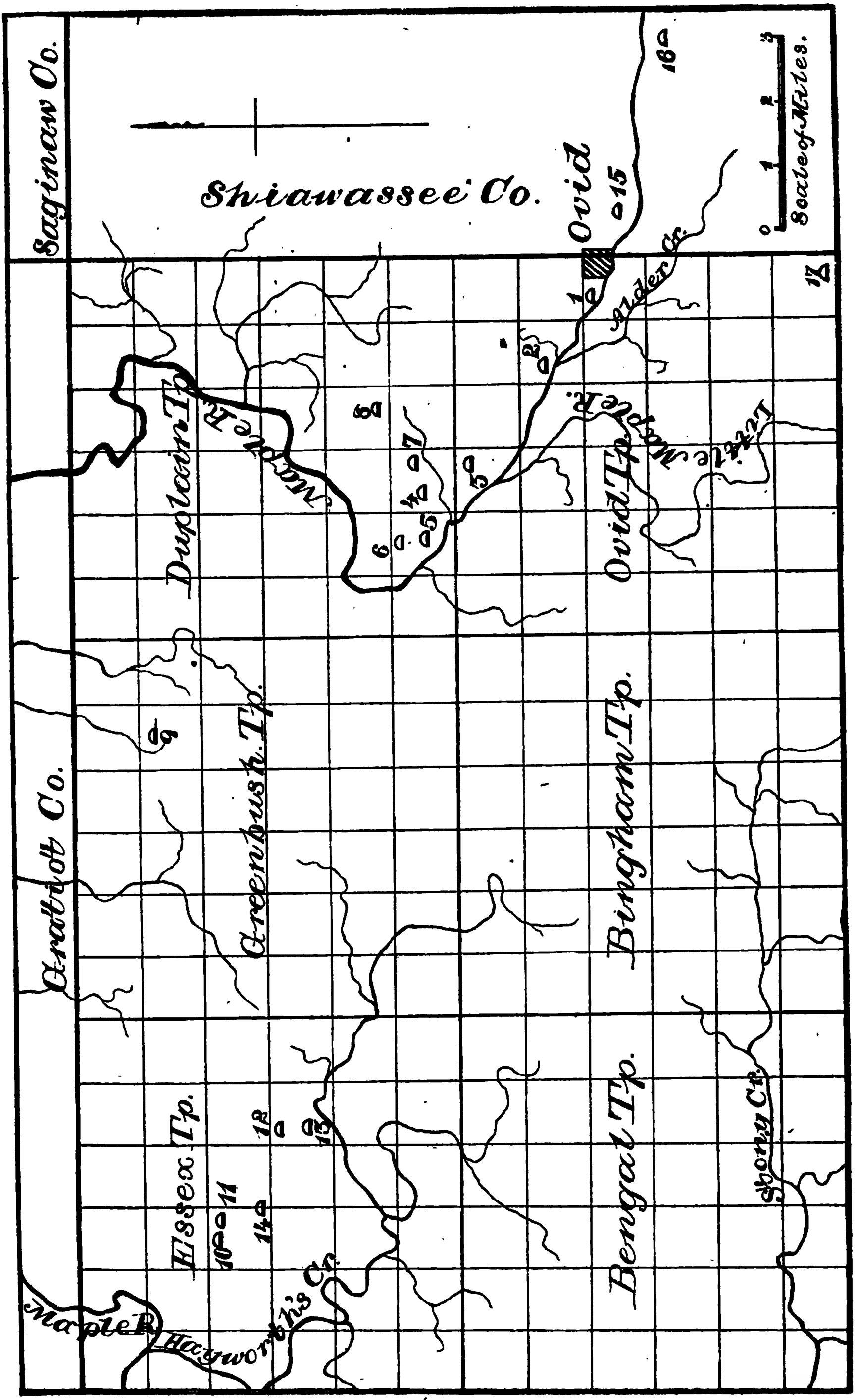
By M. L. LEACH, *of Traverse City, Mich.*

Clinton County, occupying a central position in the Lower Peninsula of Michigan, is one of the most fertile portions of the State. The northern part of it is watered by the Maple River and its tributaries. The Maple is a small, sluggish stream. Rising in the central part of Shiawassee County, it takes a northwesterly course through the townships of Owosso and Middlebury, in Shiawassee, and Ovid, in Clinton; turns sharply to the northeast, then to the west, and finally to the north in the township of Duplain; crosses the boundary into Gratiot County, runs a westerly course for 13 miles, and re-enters Clinton near the northwest corner of the township of Essex.

It is only of the townships of Middlebury, Ovid, Duplain, Greenbush, and Essex that we have to speak in these notes. All the five townships lie wholly within the Maple River Valley. The surface of the country is gently undulating. There are no high hills or deep valleys. The land slopes down to the margins of the streams, generally without any well-marked terraces. There are some extensive swamps and marshes. The soil of the higher lands is a rich, sandy loam, easily cultivated, adapted to general farming, and remarkably well suited to the production of the cereals. When first settled by the white men, large portions were covered with heavy forests of oak, maple, elm, beech, basswood, and ash, with patches of pine interspersed; other parts were what is there called plains, being comparatively level, with an open forest consisting almost wholly of oak.

The Maple River Valley was the seat of a populous settlement of the Mound Builders. Their remains consist principally of burial mounds. These stretch in an irregular line, in a northwesterly course, from the township of Middlebury, through the most fertile part of the valley, to the northwestern part of Essex. The accompanying map is sufficiently accurate for practical purposes. I have taken great pains to ascertain the position of most of the mounds relative to the lines of the Government survey. When the location is given without qualification, it may be relied on as correct.

The mound on the southeast quarter of the southeast quarter section 36, in Ovid, marked 17, has entirely disappeared before the



Map showing mounds in northwest part of Clinton County, Michigan.

march of the white man's improvement. Mr. Hugh Swarthout, of Ovid, from whom I have the account, says it was 30 feet across at the base and as high as a man's head. Forty-three or forty-four years ago, he, with others, dug down in the center of it, and found bones at or near the natural surface of the ground. A tibia taken out was at least 6 inches longer than that of a man 6 feet high. The bones were all large. Though Mr. Swarthout is reliable, it is not safe to trust reports of big bones and other wonders, as I have learned by experience.

About the location of the mound there is no doubt.

Of the group of mounds in Middlebury I cannot give the exact location. I visited them once when called to the neighborhood on business, but took no notes. There were six or seven of them, all of which had been leveled by several years' use of the plow and harrow, but the site of each was still plainly discernible at a long distance.

From this group, passing down the Maple 2 or 3 miles, we come to another interesting group, marked 15 on the map, on the farm of Malcolm Fitch, about 1 mile east of the village of Ovid. In July, 1878, I visited this group, in company with my friend the late W. S. Trask, of Charlotte, Mich. With the assistance of Mr. Fitch's son, I took some rough measurements while Mr. Trask was sketching. There were six of the mounds, situated on level, sandy land, in a beautiful grove. The largest was 34 feet in diameter at the base, circular, and well rounded up. It was 4 feet high, but the height may have been somewhat increased by the earth thrown out of an excavation in the center by some explorer. A portion of a tree which had grown on the mound was still lying upon it. It was 2 feet or more in diameter. Mr. Fitch said it must have fallen down before he came to the place, twenty-seven years previously. Southeast of this first mound, at a distance of 18 feet from its base, we came to the base of another. It was somewhat irregular in shape, being 50 feet long from east to west, 30 feet broad, and from 2½ to 3 feet high. Mr. Trask suggested that the two mounds were part of a natural ridge, and that the earth from the space between them had been removed and added to the northwestern extremity of the ridge to complete the first mound, leaving the remaining portion of the ridge with the appearance of an artificial structure—an opinion with which I do not coincide. Measuring 90 feet from the eastern base of the second mound, in a southeast direction, we came to the base of the third. This mound was irregularly oval in outline, being 30 feet long from north to south, 25 wide, and 2 feet 3 inches high. Growing on top was a white-oak tree 2 feet 3 inches in diameter, 3 feet from the ground. Trees of various sizes, but smaller than this, were growing upon the mounds already described. Southeast from this third mound we came to a fourth. From an omission in my notes, I am unable to give the distance. It may have been anywhere from 20 to 100 feet. On account of the same omission, I am unable to draw a plan of the group. The mound was small, and flat. Twenty feet southwest of

it was another small, flat mound, and 180 feet northeast of No. 2 was another of the same character. My recollection is that none of this group except No. 1 had ever been disturbed. It is a matter of regret that I did not have an opportunity to make internal explorations of the more important ones.

In the western part of what is now the village of Ovid there formerly existed a group of small burial mounds, marked on the map. They were long since destroyed by the cultivation of the land. I have an account of them from Mr. Dennis Birmingham, of Ovid Township, who is not unfamiliar with the works of the Mound Builders, and would not be likely to be deceived.

Continuing on down the Maple, in a northwesterly direction, something like a mile and a half, we come to the site of two small mounds, marked 2. The location is 30 or 40 rods west of the center of section 11. They are situated on a tract of rich, loamy soil, with a mixture of fine gravel, heavily timbered with several varieties of forest trees. The tract slopes gently down from higher land at the north till it blends with the Maple River bottom at the south. At the west it terminates in a bank or bluff about 12 feet high, 50 or 60 paces distant from the larger mound. At the foot of the bank is an ancient channel of the river, with low, wet bottom land beyond. It is not improbable that the river flowed through this channel at the time the country was occupied by the Mound Builders, though it is now found some distance farther southwest. The larger mound, measured by the eye, at the time of my visit was not more than 16 feet in diameter and 2 feet high. There was a shallow trench all around its base, from which, no doubt, a portion of the earth for its construction had been taken. Excavations had already been made in both mounds. In the vicinity of the mounds were a large number of "dug-holes." They were generally circular, some of them having a raised margin made by the earth thrown out, while around others the ground was level up to the very brim, as if the excavated earth had been carried away to aid in the construction of the mounds. Perhaps those with raised margins may have been made by the modern Indians for burying their corn. Possibly the Mound Builders also buried their corn in the same manner. It is not always easy to distinguish between the dug-holes of the Indians and those of the more ancient people.

Continuing down the valley of the Maple, in a direction almost due northwest, for a little more than 2 miles, we come to the site of the mound marked 3, on the northeast quarter of the northeast quarter section 4. This mound has disappeared in the process of cultivation. Mr. Gleason, the owner of the farm, describes it as 16 feet broad and 2 feet high. I remember that many years ago, when hunting there, while Mr. Gleason's farm was still a forest, the deer I was tracking walked over this mound, and I stood for some time on its summit, peering into the surrounding forest for signs of the game. My attention had not at

that time been called to the works of the Mound Builders, and I did not recognize the real character of the curious little hill I stood upon. My recollection of it is that Mr. Gleason's estimate of its diameter is correct, but that it was fully 3 feet high. Mr. Gleason and others dug into it and took out a skull. They saw a large quantity of bones.

Going again to the northwest, at the distance of something more than half a mile, we come to an interesting group of mounds, marked 4, on the east part of the east half of the southwest quarter section 33, in Duplain. Leaving out of the account several small, slight elevations about the character of which there was doubt, this group consisted of four well-defined mounds. The largest one was oblong in shape, being 25 feet long, 20 feet wide, and 2½ or 3 feet high. Lying south of this, their bases almost touching, was another oblong mound, 2½ feet high, 22 feet long from east to west, and 14 wide. Southwest from the principal mound, distant 20 feet, was the third one, 3 feet high, 25 feet long from north to south, and 15 feet wide. All around these three the earth appeared to have been scooped out for the purpose of building them. The fourth mound of the group stood apart from the others, about 16 rods distant, in a southwesterly direction. It had been opened, and it was said that bones had been taken out. It was circular, 20 feet broad at the base and 3 feet high.

In 1877 and 1878 I made thorough examinations of the three mounds situated near together. The largest one was nearly all dug away, and a broad trench, reaching down below the natural surface of the ground, was carried through each of the others in its long diameter. In all three, with the exception of a surface layer a foot thick, the soil, a gravelly loam, was extremely hard and apparently impervious to water. It was the opinion of Mr. Trask, as well as of myself, that it had been rammed hard around and above the bodies. Forming an impenetrable protection to the bones, it has, in a great degree, preserved them from decay. In two or three cases the periosteum was found still adhering to its bone.

In the large mound were found six skeletons, besides some scattering fragments. Each of two lay alone; the other four were in pairs. In the case of one of those buried singly, as nearly as could be determined, the body had been laid on the back, the head to the east, the legs flexed under the thighs so that the heels were near the pelvis, and the head raised in such a position that, as the bones settled together in the process of decay, it rested on the left shoulder-blade. It has occurred to me since that it may have been buried in a partly sitting posture. The other skeleton that lay alone had been carefully disposed for burial. It had been placed in a shallow, short grave (before the mound was built), with the face to the north, the head to the east, the legs and thighs flexed as much as possible, with the head a little elevated. One pair had evidently been as carefully placed, with the thighs and legs flexed in the same manner, with the heads to the east, one looking north

and the other south. The bones were in such close proximity that the backs of the heads and bodies must have touched. The order and regularity of this burial produced the conviction that the two bodies were buried at the same time. The position of the other pair could not be satisfactorily made out, but one skull lay above the other. All these graves were at or just below the natural surface of the ground.

In the mound lying south of the one just spoken of three skeletons were found. The first lay in the western half of the mound, a little below the natural surface of the ground. It had been placed on the back, with the head to the east and slightly elevated, the thighs and legs somewhat flexed, and the right arm flexed so as to bring the palm of the hand upon the upper part of the right side of the chest. Above the left shoulder lay a heavy stone ornament, charm, or token, of a blue color when first exhumed, but turning black on exposure to the air. It was 4½ inches long, 2¼ wide, and seven-sixteenths thick, slightly bent, and shaped a little like a hoe or an adz. There is a hole through the narrower end, by which it may have been suspended by a string from the neck. It appears to have been made from a stone that required but little fashioning to bring it to the required shape, as it showed but little polishing, and in spots the rough, natural surface could still be seen.

This was the only manufactured article found in any of the mounds examined by me in this part of the State. The second skeleton we came upon was in the upper portion of the eastern half of the mound, the skull, which was the most elevated part, being not more than 8 or 10 inches below the surface. It lay upon the back, the head to the east, the shoulders elevated and the head tipped forward upon the chest, the pelvis a little elevated, and the thighs and legs completely flexed. There was a cut through the skull. Mr. Trask was of the opinion that it had been made before burial, and was the cause of death. I think it was accidentally made by the spade in excavating. The third skeleton was found at a lower level than the second, but not directly under it, a little nearer the north side of the mound. Like many of those found in the same group of mounds, it lay with the head to the east, on the right side, the head a little elevated, with the knees drawn up to the chest and the heels to the pelvis. A peculiarity in this burial is that the hands were placed in contact with the face.

Not the least interesting and instructive of the mounds of this group was the one situated a short distance southwest of the principal one. A little north of the center, a foot and a half below the surface, I came upon what, for want of a better name, I call an ancient fire-place. It was simply a level surface, made upon the mound when only partly built. I uncovered it with the greatest care, working for hours upon my knees, scraping away the superincumbent earth with a common table-knife, so as not to displace anything that might be of interest. When done, I had before me a bed of ashes, mixed with charcoal and burnt sand, on which lay the bones of a partially burned human skele-

ton. At the bottom of the mound, just below the natural surface of the ground, were the remains of two skeletons, one under the north half of the mound, the other under the south. Both appeared to have been carefully disposed for burial, according to what seems to have been an approved mode—on the right side, the head to the east and slightly elevated, with the thighs and legs flexed so as to bring the heels near the pelvis. The following facts in the history of this mound are palpable: Two bodies were laid in shallow graves and a mound partly built above them; on a level spot on the partially built mound a fire was kindled and a human body burned; then the bed of ashes and the remains of the burned body were covered up with earth by the completion of the mound.

Continuing on down the valley, but bearing more towards the west, we come to what was probably the largest mound in this part of the country, situated on the northwest quarter of the southeast quarter section 32, on the farm of Edward Paine. It is marked 5 on the map. When my attention was first called to it, not only had excavations been made in it and the bones of several skeletons found, but more than half the earth of which it had been composed had been carted away for use elsewhere and the remainder was in process of removal. In order to improve what little opportunity for investigation remained, I volunteered to wield the spade during the completion of the work. Before this mound had been disturbed it was nearly circular in form, being 40 feet broad from east to west and a little less from north to south. According to the best information I can get, and I think it reliable, it was 4½ or 5 feet high. At one time three skulls and a quantity of bones were taken out. Mr. Paine says the skulls were found close together in the north part of the mound, and, though no special care was taken to observe the position, he thinks the three skeletons lay in a horizontal position, with the heads to the north. During the removal of the last portion of the mound, at which I assisted, nothing of interest was found except a fire-place. This was situated some distance below the surface, in the southwest part. The remains consisted of charcoal and burnt earth mixed with a considerable proportion of a sooty substance having the appearance of lamp-black. A careful examination of the charcoal, which was in small pieces and very soft, convinced us that the fuel had been largely pine wood. The fire had been kept burning for some time in a hollow or pit in what was then the unfinished mound. It had afterwards been covered up by additions made to the mound. No burnt bones or remains of artificial objects were found. Mr. Paine informs me that at a little distance southwest of this large mound were formerly several small ones, all of which have long since disappeared under the operations of the farm.

About 100 rods distant from the mound, on Mr. Paine's farm, in a direction a little west of north, on the same section, there was formerly

a mound of considerable size. It is marked 6 on the map. It had been worked down with the plow, when I saw it, till only a slight elevation remained visible. It was said to have been 25 feet broad at the base and 4 feet high. I made extensive excavations on its cite, but found nothing. Mr. N. W. Brass, who was brought up from childhood in the vicinity, informs me that there was once a small one near it.

Let us now return to group No. 4, on section 33. Going from that point a little more than half a mile in a northeasterly direction, we arrive at the location marked 7, on the northeast quarter of the southeast quarter of the same section, on the farm of Charles Dailey. Here were formerly a great number of small mounds, scattered over a considerable area. That they were burial mounds, and not natural undulations of the surface, was proved by digging into them. All of them have disappeared.

Something more than a mile farther to the northeast, on the farm of H. B. Smith, on the southeast quarter of section 27, we come to the site of another mound, marked 8, all traces of which have disappeared. My wife, who was among the early settlers, remembered it well, and confirmed the accounts of it received from others. Mr. Smith represented it as 30 feet or more in diameter and 4 feet high. A small excavation was once made in it and a skull taken out. When I visited the place two thrifty peach trees were growing where the mound formerly stood.

I forgot to mention, in connection with group No. 4, that there are several dug-holes a short distance from the mounds. They are all perfectly circular and perfectly bowl-shaped. I carefully cleaned out one of them, examining every spadeful of earth thrown out, but found no relics. When cleaned out to its original size, as nearly as I could judge, it was 7 feet in diameter and 3 feet deep. There is no raised margin about any of them.

The only mounds in the township of Greenbush of which I have any knowledge are situated on section 11. One, marked 9, which I visited in July, 1878, was about 20 rods north and the same distance east of the center of the northwest quarter of the section, on the farm of P. Jefferys. It was in a grove of heavy oak timber, in a tract of country considerably broken by low hills. Its form was circular. I did not measure it, but judged that it was 35 feet in diameter and 4 feet high. Mr. Jefferys informed me that, before it had been disturbed, there was a perfectly level area 12 or 15 feet in diameter on the top. It was, in fact, according to his description, a regular truncated cone. Somebody had made a large excavation down into the center. It was reported that nothing was found. Another mound, said to be broader and flatter than the one above described, was reported to be situated 40 or 50 rods southwest of it. I spent considerable time in searching for it, but the forest being filled with an undergrowth of shrubs and small trees, almost impenetrable, I was not successful. Of its existence, however, there is no doubt.

In regard to the mounds in Essex, I cannot do better than to copy *verbatim* my notes taken during a visit to that township in July, 1878.

The tract of country occupying the central portion of Essex seems to have been a favorite place of residence of both the Mound Builders and the red Indians, as it is now of the whites. In point of fertility, ease of cultivation, and large returns for agricultural labor, it is seldom excelled. When first known to the oldest of the present residents it was covered with patches of thrifty hazel bushes, alternating with patches of a rank and nutritious grass. Oak trees of considerable size were scattered over its surface.

About 118 rods west of the northeast corner of section 16, and perhaps 25 rods south of the section line, the remains of a mound (10) are still to be seen. The field in which it is situated has been under cultivation for, perhaps, thirty years, and the repeated use of the plow has reduced the height of the mound as least one-half. The same agency may have also increased its apparent area and somewhat changed the form of its surface. At the present time the length of the base is 50 feet; width of the base, 35 feet; height from the natural surface of the ground, 2 feet; height from the bottom of the broad and shallow trenches around it, from which the earth was apparently taken for its construction, 3 feet. The long axis lies nearly east and west, but inclines a little (perhaps 5 or 6 degrees) to the southeast and northwest. The east end is bold and well defined; the west not well defined, the mound sloping gradually from the junction of its eastern and middle thirds to the natural surface of the ground at its west end. The earth for its construction appears to have been scooped up around its base, but principally in three places—around the east end and along both sides of the western part. At about the junction of the eastern and middle thirds, corresponding to the highest part of the mound, the earth appears to have been left in place on each side, forming a passage between the excavations to the foot of the mound, and, perhaps by artificial additions made to it, a graded way to the top. The soil is a sandy loam, with a small admixture of gravel. I worked with a spade for three days in succession, and made extensive excavations in it, but without finding relics or any evidence of the use it had been put to. A short distance easterly from this mound is a smaller one, situated directly in the line of the axis of the larger, which has nearly disappeared under the plow.

On the south part of the northeast quarter of the northeast quarter section 16 is another mound (11,) but a little less in size than the of preceding. Its form is circular. According to measurements that I made, its diameter at the base, at the present time, is 40 feet, and the height above the natural surface of the ground 22 inches. There is a broad and shallow excavation all around it, from which the earth for its construction was taken. Its height has been diminished by the plow at least one-half. Mr. James Soule was familiar with it before the land

was improved. He says there was an oak tree growing upon it, which, when cut, many years ago, measured 32 inches in diameter at the stump. At a short distance east-northeast of this mound is plainly to be seen the remains of a smaller one.

On the northwest quarter of the northwest quarter of section 23 are two mounds (12) of no great size. They are near together, one west of the other, on a ridge running east and west. They are plainly seen, but are fast disappearing under the plow.

There are two small mounds (13), near together, about 85 rods north and 33 west of the center of section 23, on the farm of Jonathan Hicks. Like those just mentioned, they are still plainly visible, but are being rapidly graded down in the process of cultivation.

There was formerly a remarkable group of very small mounds (14) on the section line between sections 15 and 16 commencing about 40 rods north of the southeast corner of sixteen and extending about 40 rods farther north. Mr. Soule says there were as many as forty of them. They were raised but a little above the surface of the ground, and are represented as having been full of human bones. A gentleman whose name I have forgotten, but whom I regarded as reliable, told me that he had frequently passed over them before they had been disturbed, that the bones in many instances were sticking up out of the soil, and that he had pried out with a stick skulls that were so protruding. These mounds, with perhaps a single exception, have all been graded down and destroyed in the construction of the highway and the cultivation of the adjoining fields.

The opinion of the people living in the neighborhood, founded on Indian tradition, is that the Essex mounds, large and small, were the graves of the dead killed in a battle between the Chippewas and Potatwatomies which occurred not many generations ago. Mr. Soule called the attention of a very aged Indian woman to the mounds and asked her their orgin. She confirmed the tradition of the battle, and affirmed that she had the account from her grandfather, who was an actor in the affair. There are many reasons for doubting the truth of the tradition as far as the larger mounds are concerned, but the group of forty small ones may possibly have been the graves of the victims of the battle alluded to. More than this cannot be conceded. The larger mounds were undoubtedly the work of the race of Mound Builders, and were in existence long before the traditional battle was fought.

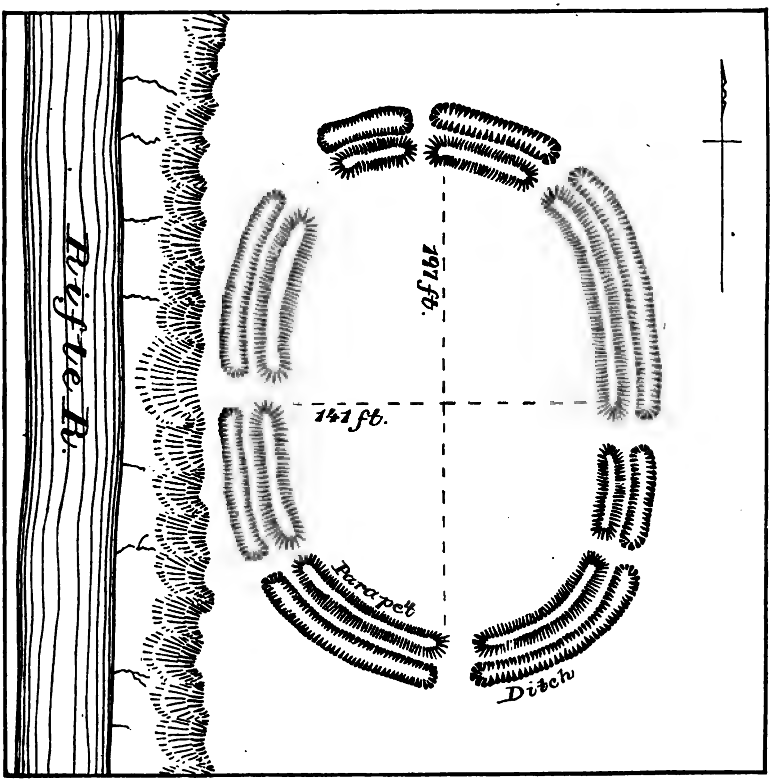
Two or three miles southwest of group 13 I saw several interesting dug-holes, but find nothing in my notes in regard to them, and cannot now give anything like a full description from memory. The exact location I have forgotten.

ANCIENT FORTS IN OGEMAW COUNTY, MICHIGAN.

By M. L. Leach, *of Traverse City, Mich.*

June 18 and 19, 1878, I examined two old forts on Rifle River, in the township of Churchill, Ogemaw County, supposed to be the work of the Mound Builders. The following is a transcript of my notes made at the time:

No. 1, the smaller of the two, is situated on the northeast quarter

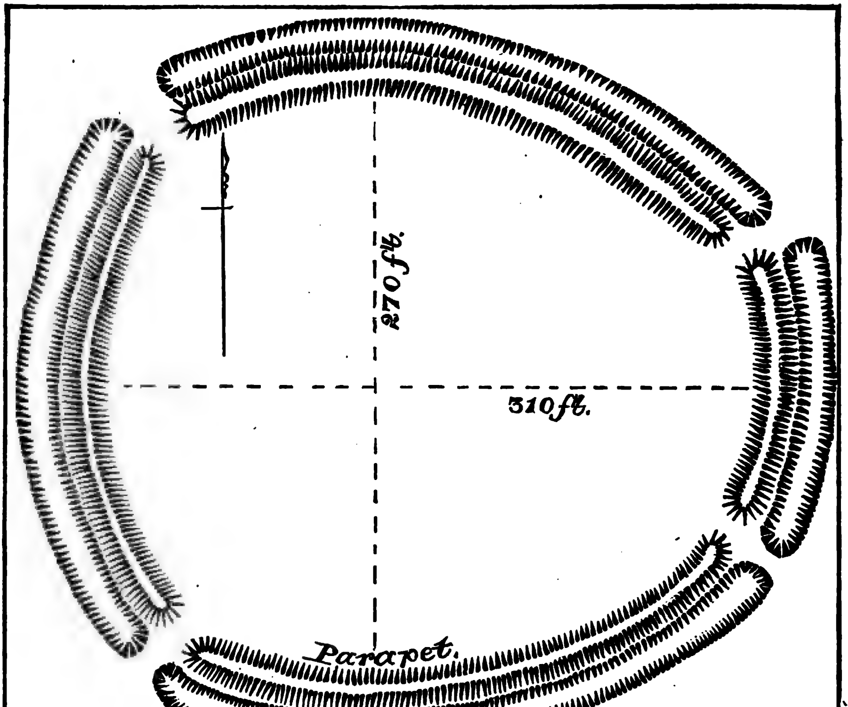


Fort No. 1, Ogemaw County, Michigan.

of section 4, township 22 north, of range 3 east, on the east bank of the river, on a bluff elevated 25 feet above the water. Its form is irregularly oval, the long diameter, from north to south, measured from center to center of the parapet, being 197 feet, and the short, from east to west, 141. The southern portion is a trifle wider than the northern. The work consists simply of a wall of earth, with a ditch on the outside. The ditch at the present time is from 2 to 3 feet deep and from 6 to 10 wide; the wall from 2 to 3 feet high and from 6 to 10 wide at the base. There are eight openings in the wall, distributed at irregu-

lar intervals, but looking towards the eight principal points of compass. The one at the northwestern curve, just on the brow of the bluff, is the widest, and may have been the principal entrance. From it the hill-side seems to have been graded down, forming a gradual and easy descent to the river. Springs of excellent water come out of the face of the bluff near the bottom all along the front of the fort. There has been a heavy growth of pine in and around the fort. A pine stump standing on the wall measures 3 feet in diameter, and the lumbermen have cut several of equal size within the area. The lumbermen have made a road, with a causeway of logs, along the springy hill-side, between the fort and the margin of the river, so that it is impossible to tell now exactly the form of the face of the bluff, but have not destroyed any portion of the earth-works. The river is about 50 feet wide, with low, wooded land on the opposite side.

No. 2, the larger fort, is about half a mile distant from the smaller,



Fort No. 2, Ogemaw County, Michigan.

in a southeasterly direction. In form it is quite regularly egg-shaped, the larger end being towards the west. Its long diameter, from east to west, is 310 feet; its short, from north to south, 270. It is a heavier work than No 1, the ditch being broader and deeper and the wall of cor-

respondingly greater dimensions. In some places the height from the bottom of the ditch to the top of the wall is fully 8 feet. Unlike No. 1, this has only four gateways or entrances. These look northeast, northwest, southeast, and southwest, and being located with great regularity with reference to the peculiar shape of the fort, the two at the eastern or smaller end are much nearer together than the other two. The one looking southwest is much wider than the others, and was probably the main entrance. The ground within the inclosed area is quite uneven, rising in the southern part considerably higher than the parapet. As far as I know, but my search was not very extended, there is no water in the immediate vicinity. Pine trees equal in size to those mentioned in connection with the other fort have been cut on the walls of this, the stumps of which are still to be seen.

No mounds, graves or other remains, have been found in connection with these forts. Doubtless, when the country comes to be cultivated, flint arrow-heads and stone hatchets will make their appearance.

The measurements given above may not be minutely accurate, as I worked alone and without instruments, except such as I could improvise for the occasion in addition to a pocket compass. The general features of the works, however, as given, are substantially correct.

Residents of the vicinity asserted that there were mounds near the river, several miles below.

A SKETCH OF FLINT RIDGE, LICKING COUNTY, OHIO.

By Charles M. Smith, *of New Madison, Ohio.*

The great numbers of flint implements, such as arrow, lance, and spear heads, drills, knives, scrapers, &c., which are found scattered through all parts of the country, frequently lead to inquiry as to the sources whence so great an amount of material may have been procured.

Under the general name of "flint," in this connection, are included various forms of siliceous stone, such as chalcedony, jasper, hornstone, chert, basanite, and even some forms of quartz that have no resemblance to flint.

The sources of supply are widespread; but before touching upon this part of the subject it will, perhaps, be well to give a short *résumé* of the different theories in regard to the manner in which is accumulated the material forming the beds, though geologists have not yet succeeded in settling this vexed question.

Quartz or silica, in its various forms, is one of the most abundant of the minerals forming the earth's crust. Hard (easily scratching glass), infusible, not affected by acids, it survives, unchanged, agencies that

will destroy nearly all other rocks. But there is one way in which it can easily be reduced: the alkaline minerals, such as sodium, potassium, and a few others, form compounds which are highly soluble; when water, especially if thermal, thus charged, comes in contact with quartz, the rock is easily decomposed and held in solution until, by cooling or evaporation, the water will not retain so much foreign matter, and the silica is deposited. In this manner is the quartz supplied which forms our agates, geodes, crystals, the concretions around hot springs, &c.

Should the dissolved silica be carried onward, however, to a considerable body of water, it tends to produce flint or its allied forms in large masses; and there are different ways in which this can be brought about. In sea-water there exist microscopic animals whose shells are formed from silica in the same manner that the shells and skeletons of mollusks and corals are formed from carbonate of lime; and upon the death of these animals their remains find a resting place upon the bottom of the ocean, and hold a limited place in the rocks formed by the limestone-makers—limited because, although numerous, these animalculæ are so small that thousands or even millions of them will not equal in bulk a single clam-shell.

Generally the flint thus formed is scattered through the limestone in such a way as to be scarcely, if at all, noticeable; in the Niagara division of the Upper Silurian age it seems first to collect itself in nodules or masses by that mysterious proceeding called "concretionary action," a *something* which has never been explained. Even when the flint lies in a regular stratum, as it sometimes does, the layer is not continuous, but is broken up into these concretions. Similar masses are found in the succeeding geological formations, especially in the Chalk-measures; in fact, some geologists claim that the only true flint is that found in the Cretaceous rocks of Europe, and that flint proper is not found in America at all. Be that as it may, the term is now too firmly attached to our siliceous rocks of this nature ever to be changed. Flint formed thus, however, is found only distributed in other rocks and does not occur in masses to itself.

The principal *flint-beds* are found in the Carboniferous age, and the manner in which they are found associated with the other rocks of the series shows another of the methods of flint-making.

In the lagoons of the present day exist immense numbers of minute plants called Diatoms, which have the power of abstracting silica from the water and using it in their plant structure. On the decay of the plant the silica is not restored to the water, but is precipitated; and if this work is allowed to continue undisturbed, in time a thick deposit is the result. As a general thing, the slower the process the more compact the stone will be; and if no tides or freshets interfere, beds of pure siliceous rock inches or even feet in thickness may be formed. Geological conditions at the beginning of the Carboniferous age seem to have been favorable for the existence of these Diatoms in vast numbers, for

in no other formation is the flint so abundant. Land-locked basins seem to have existed along the border of the ocean in that period, wherein our little plants flourished, while farther out the limestone was being formed by such animals as find their most suitable surroundings in open salt water; so that one has only to lay before him a section of a coal-shaft, suppose this shaft to have been made through rock of which some limestone layer was formed near the shore in quiet water, substitute "flint" for "limestone," and the explanation of flint-beds is at hand—such, at least, as are due to this vegetable agency. It is not to be inferred, however, that all flint should for this reason present the same appearance; there are to be taken into consideration the chances of occasional slight changes of level; tides and storms bringing in a supply of salter water, with, it may be, many lime-producers; the swelling of a tributary stream; where-by various organic and inorganic impurities are carried in to a greater extent, coming sometimes from one kind of soil, sometimes from another—all these points, and others, are to be remembered in accounting for the different grades and colors found even in a limited space.

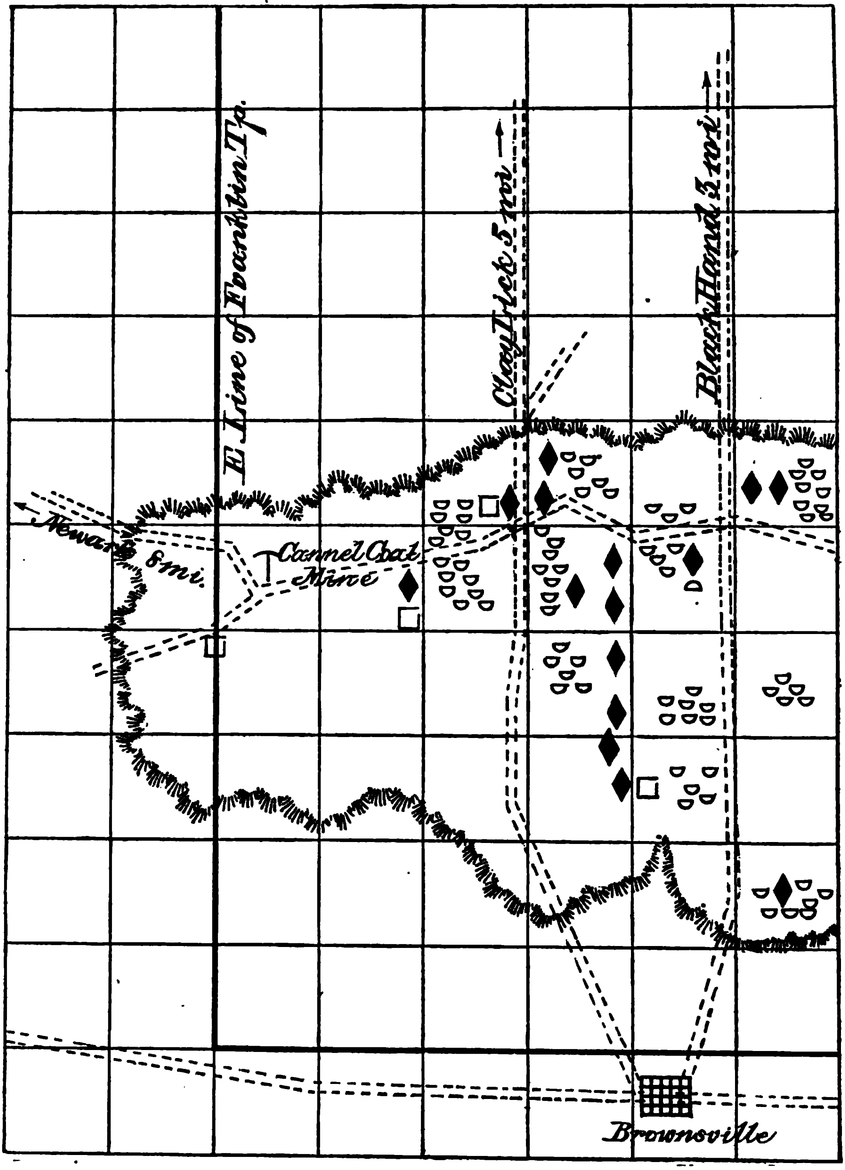
These are the most common explanations. Recent investigations go to show that chemical changes at the bottom of the ocean have much todo with flint formation; and the process of substitution, whereby silica replaces other material in decaying substances, as is seen in the petrifaction of woody fiber, adds its mite to the limited knowledge of the subject; but the question is far from being definitely settled.

Throughout Eastern Ohio there are numerous deposits of flint of various descriptions; and in several counties places are to be found in which the "ancient arrow-maker" practiced his calling with the material so abundantly supplied.

Pre-eminent among them, on account both of its great extent and the vast amount of aboriginal labor evident throughout nearly its whole extent, is the deposit lying in the southeastern part of Licking and western part of Muskingum Counties, Ohio. This has been known for many years as "Flint Ridge," and, numerous as are similar deposits in other places, it is by all odds entitled to be called *the* "Flint Ridge" not only of Ohio but of the whole country.

Its most western point is on the road leading from Newark to Zanesville, about 8 miles from the former place and half a mile from the eastern line of Franklin Township. From here it extends eastward across Hopewell Township and about 2 miles into Muskingum County, making its entire length very nearly 8 miles; counting by section lines, and fully 10 miles following the turns of the road. At about 2 miles from its western end, north of the village of Brownsville, it reaches its greatest breadth, 2½ miles. Owing to the extensive erosion that has taken place since its final emergence from the ocean (the summits of the hills being more than 300 feet above the streams), its outline is exceedingly

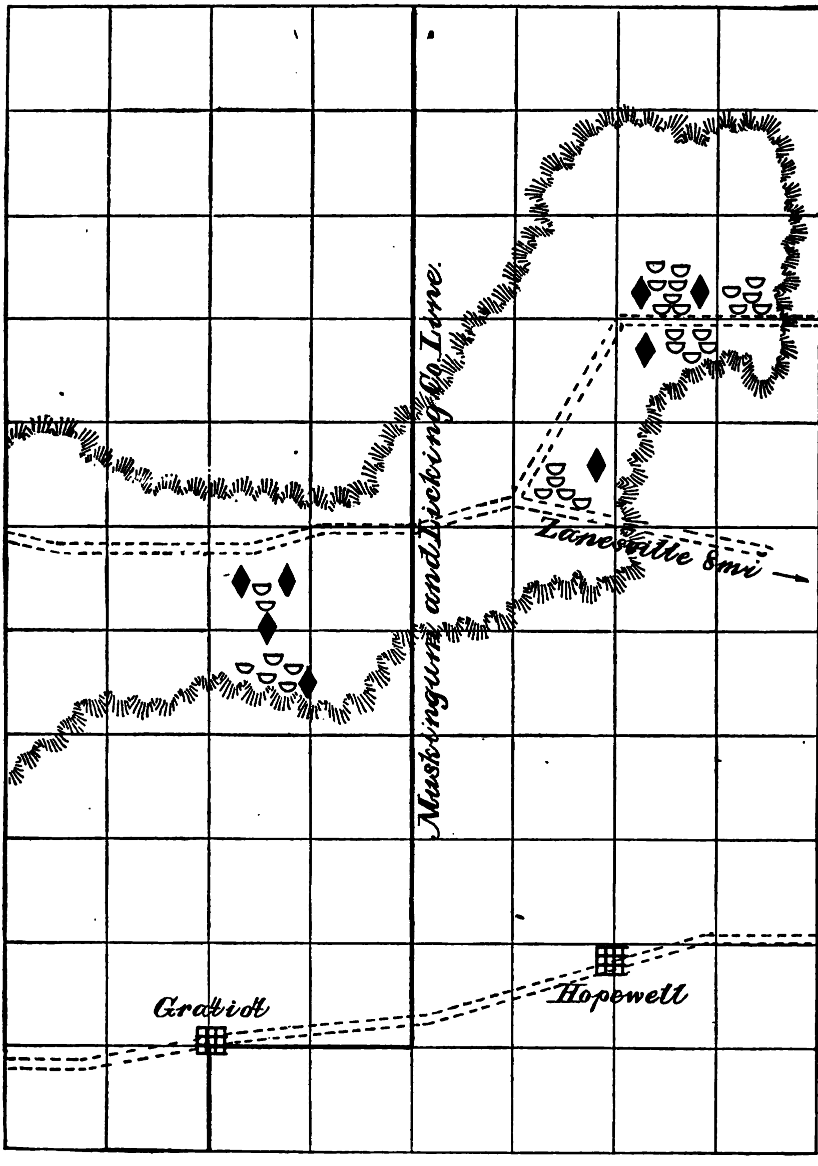
irregular. The surface is undulating, but on the ridge proper is level enough to admit of a good road along its whole extent, while long spurs on either hand extend to north and south. Judging from the extent



Flint Ridge, Licking and Muskingum Counties, Ohio.

and direction of these spurs and the outlying ridges, the whole deposit was of an irregular crescent shape, with the convex side to the south and southeast. The road from Newark to Zanesville, called the "ridge"

road, winds along close to the northern edge for about 6 miles, when it passes across the curve of the crescent, leaving it to the north.



Flint Ridge, Licking and Muskingum Counties, Ohio.

The dip of the strata in this region, as in nearly all the eastern part of Ohio, being to the southeast, the flint at the western end of the ridge is very near the surface, while at the eastern end it is about 80 feet below the highest points, the country holding about the same elevation above the sea-level.

The flint, from its great resistance to weathering agencies, forms the cap-rock of the whole ridge, the superincumbent material being for the most part either clay or soil resulting from the disintegration of the shales and sandstones which formerly existed at this horizon. The natural place of the Kittanning coal of the Pennsylvania series is 15 to 20 feet above the level of the flint, but it runs out before reaching this far west—at least there is no trace of it here. Thin beds of bituminous coal lie at different levels in the hills; 104 feet below the flint is a workable seam of cannel-coal. A section of the formations in the eastern part of Licking County shows the same alternation of sandstone, shale, clay, coal, limestone, and iron ore that is found in all coal regions, so that a detailed statement of its geological structure is unnecessary in this connection.

Did the topography of the country depend upon surface drainage alone, the flint would act as a protection to the rocks below, and the whole ridge present a more symmetrical outline than it does; but, owing to the numerous crevices existing in it, and to the porous nature of the greater part of the underlying strata, water easily passes downward until it reaches the stratified beds of clay, along which it makes its way to the open air. The springs thus created have worn their way back, by the destruction of the adjacent rock and the consequent displacement of that farther away, until the whole region is a succession of steep hills separated by narrow ravines.

It is difficult to determine the thickness of the flint at any point without cutting through it, as the outcrop is so weathered and broken as to offer no safe basis for estimate. A few wells have been dug through it, and the thickness is given at different points at from 4 to 7 feet. It probably varies, owing to slight irregularities of the bottom on which it was deposited, and the more favorable conditions in some places than in others for the multiplication of the flint-making agents. It is thickest at the eastern end, according to persons living there.

In the fourth range of sections in Hopewell Township, counting from the western line, between the farms of Samuel McCracken and Lennox Fisher, is a break of three-fourths of a mile in which no flint is found, erosive agencies having removed all the rock for 20 to 40 feet below the level of the flint stratum. Beyond this it reappears, and continues unbroken to its eastern limit in Muskingum County.

In the geological scale this flint is continuous with the ferriferous limestone of Southeastern Ohio, and is highly fossiliferous in some places. In the museum of the State University is a very fine nautilus imbedded in a piece of buhr-stone from this place. Other smaller fossils occur abundantly both in this and the more solid flint, particularly *Fusulina cylindrica*, a small foraminifer found in great numbers in Europe at a corresponding horizon. Very frequently, however, the fossil, being calcareous in its nature, has disappeared, and only the matrix remains.

Underneath the flint lies the "Putnam Hill limestone" of the Ohio sur-

vey, so named from a high hill opposite Zanesville where it is well shown. The upper part of this limestone is shelly, sometimes closely approaching a thin sandstone in its appearance, and of a yellow cast; farther down it becomes more solid and takes on a blue color.

The flint varies in its nature in different parts of the ridge. It is impossible to gain an accurate knowledge of its appearance in many places without excavation; but, so far as can be judged from the outcrop and the reports of the well-diggers, the following will be found not far out of the way:

At the extreme western end the stone is of a gray or whitish color, cellular or porous in its structure, and of the sort commonly known as "buhr-stone."

By the oxidation of the included iron, it shows various shades of yellow or brown along the lines of fracture.

Half a mile east of this appears a translucent, bluish variety, fragments of which are seen scattered in the fields or along the outcrop. Still, the buhr-stone seems to predominate.

Two miles east, in the neighborhood of the cross-roads, the flint changes considerably. There is to be found every color and shade ever seen in such stone. White, red, black, brown, yellow, green, and blue, in various shades, occur plentifully in the pieces around the fields and where the flint shows in the hill-sides. This coloring is all due to the oxidation of the iron and organic impurities contained in the flint, as may be shown by digging to the bottom of one of the bowlders which shows different colors on its top; on reaching a part that is unweathered it is generally found to be of the same bluish tinge as the greater part of the bed-rock.

Near the intersection of the ridge road with the one leading from Brownsville to Clay Lick Station (on the Baltimore and Ohio Railroad), which, for distinction, is called the cross-road, the well-diggers report that the flint is light blue and translucent. A few hundred yards north it is nearly white, while at the same distance south a layer of a very dark shade is reported at the same level by parties who sunk a shaft here many years ago "to see what was down there." To determine what was meant by "dark flint" it was decided to clear out the trash that had blown into the shaft and examine the flint in its place; and this is the result:

Commencing at the edge of the shaft, the flint was found at 3 feet under the original surface, but as this was near the outcrop it is not to be taken as the full thickness of the overlying dirt, for there is a rise of several feet from this point to the top of the hill. Under this soil was a layer of flint of a grayish color, which must be very limited in extent, as no pieces of it are found in the "work-shops."

Next was the "dark flint," which is further mentioned on a following page. This flint contained a large amount of iron sulphide, which has oxidized along the seams, the iron giving a rusty-looking coat to the

stone, which is not solid, as in some other places, but is in thin layers, between which a thin parting of clay is occasionally found.

The total thickness of the flint here was 29 inches. Next is a layer of bluish clay; on the top of this the sulphur set free by the decomposition of the sulphide had collected in a thin veneer.

The clay continues pure only for 2 or 3 inches; then sand appears mixed in with it; a little lower some lime also enters; next it is in thin plates; and finally, at 16 inches, it runs into the solid limestone. The clay is quite soft, but as the sand and lime become mixed with it the whole grows harder and more compact.

This same black flint is found east of here, beginning near the next section line and extending eastward for half a mile, and also at the extreme southeastern spur of the ridge.

A grayish, banded flint, presenting very narrow stripes of white or light gray, alternating with darker shades of the same color, is found a few hundred yards southeast of the cross-roads in rather limited quantity. On the farm of Joseph Duncan the same flint occurs in great abundance, the whole outcrop being of this nature on a point north of his house.

At the eastern end, along the Muskingum line, the flint has much the same appearance as at the western end—a buhr-stone that has been quarried to a considerable extent by the whites for making mill-stones. At the eastern termination of this stratum a white flint is found, having occasionally places in which iron has given it a reddish tinge.

It would seem, so far as can be judged from the limited opportunities for examination, that at the edges of the deposit, on every side, it is more in the nature of the buhr-stone, while through the central part, probably owing to clearer or less disturbed waters, the formation of a denser, purer siliceous rock was possible. Scattered around the pits, to be spoken of later, south of the blacksmith shop, at the cross-roads, near where the "shaft" mentioned above was sunk, can be found all the colors and shades mentioned, while farther away, in all directions, it seems to be of one general character. Much of it answers to the description of chalcedony, nearly all at the central points being translucent or even transparent. The so-called "black flint" is not the opaque variety, basanite, found in other parts of the Coal measures, but a clear, vitreous kind, containing a large amount of iron and carbonaceous matter, to which its color is due. This is proven by finding pieces almost perfectly transparent from the absence of impurities, and ranging from that to a deep black that is translucent only in the thinnest flakes. Some of it has the coloring matter so distributed as to resemble moss agate very closely; a variety occurs which has a beautifully mottled or clouded appearance, due probably to the entanglement of some gas in the silica at the time it was deposited, the cloudy part being sometimes in spots, again in narrow stripes, and occasionally in bands, which make it resemble small

concretions. Agates cannot exceed in brilliancy or delicacy the beautiful markings found in many of the fragments.

In nearly all the crevices in the flint, so far as digging by searchers goes to show, are found quartz crystals. These are of more recent origin, being formed by the evaporation of waters of infiltration carrying silica in solution. They vary in size from those which are microscopic to those as large as a hen's egg. Some are limpid as pure water; others are charged with carbonaceous matter, and sometimes in such quantity as to make them almost black. They are all short, the terminating pyramidal point frequently being all there is to them Generally they are found adhering to the face of the rock, though sometimes they may be found in the soil filling the crevices. In the latter case it is probable that the flint holding them has weathered down and they have fallen off, as crystals formed free or unattached to a base generally terminate in a pyramid at each end, a shape not found here.

Baryte and calcite are found occasionally, filling cavities in the flint.

A few dollars' worth of gold was washed out of the sand in the bank of a little stream on the south side of the ridge a few years ago, and stories of various Indians and Californians who know the location in these hills of nearly all the metals of the globe can be heard from every man who lives within miles. No doubt minute quantities of various minerals can be found such as occur in all geological formations; but coal and clay will be about the only sources of wealth that can ever be made available beyond the agricultural productions of the country. The land is admirably suited to the growth of grass, and this, with the abundance of pure water in every ravine, must make stock-raising the most profitable occupation in which the people can engage.

Now, as to the evidences of prehistoric industry.

The blacksmith shop of John Loughman, at the cross-roads, 3 miles north of Brownsville, is a central point from which distance and direction can be estimated, and has the advantage of being well known to every one for miles, so that a person can easily take it for a starting place.

It is not until within half a mile of here, coming from the direction of Newark, that pits opened for the purpose of obtaining flint begin to appear. The western end of the ridge was for some reason left untouched; probably it can be explained when we come to speak of the evidences of settlements; at any rate, the rock could have been easily quarried, and seems as well adapted to purposes of manufacture as at other places.

The pits first appear on the north side of the ridge road, and extend in a northwest direction, along a spur of about one-fourth of a mile in length, nearly to its termination. A ravine heads, near the road, east of this spur, and the next pits are found on the eastern side of this ravine, on the farm of Alexander Miller, whose land extends to the cross-roads.

The flint lies nearer the surface here than on the south side of the road, which at this place is about 500 yards south of the northern limit

of the flint; and this space, occupied by the farms of Loughman, Miller, and Feegan, has pits over nearly its whole extent. Southwest of the blacksmith shop, on the farms of Loughman and Vermillion, the pits extend nearly half a mile, mostly in uncleared ground, as the succession of holes and ridges where they have been dug makes it impossible to cultivate what little soil may be found among the rocks. The holes grow larger and deeper as the spur extends south, until at the end some occur which measure 60 feet across. Just how deep they may be cannot be told except by cleaning them out, as they are partly, or in some cases wholly, filled with dirt and decayed vegetation. They nearly always contain more or less water, the present summer being the first one in many years that they have been dry. Jumping or throwing a heavy stone in them causes the whole surface to tremble, showing that the muck filling them is still soft and spongy below, and the length of time this trembling continues indicates a considerable depth. South of Miller's house, and east of these just mentioned, are a few, but they are small, and the amount of débris around them shows their depth to be inconsiderable as compared with the larger ones.

Ten or twelve acres have been dug over on the western side of the cross-road; that is, if the actual area excavated be measured it will amount to that much, though the pits themselves are scattered over several farms. The spurs are narrow, and in many places there is a considerable interval between the points in which the work has been carried on; those lying on the southern spur, however, are close together, and very great labor has plainly been expended on them.

On the east side of the cross-road the holes increase in size and number.

North of the blacksmith shop are about 6 acres every rod of which has been dug over. Many of the pits here hold water the entire year. They are mostly shallow, as the soil is thinner here than at other points in the excavated district; some are filled with muck, while others contain very little trash. This field has been cleared and cultivation attempted in such parts as can be plowed, but without much success, as the amount of loose flint heats the ground to such an extent in summer that everything dries up.

East of these, in a piece of timber, are 2 acres of larger and deeper pits. Then, scattered at irregular intervals, are a few, single or in small groups, extending for about half a mile east of the shop, when there is a break in the work and no more are found on the north side of the road for nearly a mile.

South of the road, on the east side of the cross-road, continuous with those described as north of the shop, and extending for about 500 yards in a direction east of south, are the most extensive excavations, both as to size and number, to be found in an equal area anywhere in the State. The part dug over sometimes narrows to 5 or 6 rods, sometimes widens out to 300 yards. Some of the pits are small, from 15 to 20 feet

across; others have a diameter of not less than 80 feet. As with them all, the depth is difficult to determine. A pole 18 feet in length has been thrust out of sight perpendicularly in one without encountering anything more solid than the muck and trash which shows at the surface; but this is scarcely a fair test of the depth, for should there be a crevice in the limestone beneath, as there well may be, for the stone has frequent joints, the slow drainage would gradually enlarge it, and the trash could thus sink to a greater depth. Besides, the ground is undulating from here to the cross-roads, and a rise of 10 or 12 feet would scarcely be noticed by any one in walking that distance along a winding path.

There can be no doubt that a greater thickness of soil lies over this particular place than over others. That the holes on this spur (which lies mostly on the land of J. G. Loughman) were much deeper originally than at any other point excavated is plain from the higher banks of dirt and broken rock piled around them. The spur is directly east of the one running south from Miller's, and the fragments lying scattered around on the two points show that the stone is of the same general character in both; in fact, the ravine between them, up which extends the cross-road, has been eroded from the middle of a local deposit that is of richer color, more compact texture, and better adapted to the needs of those using flint implements than is any other part of the whole ridge. It is at these places that the most beautifully colored pieces are found, and there is no doubt that if some of these deepest pits were cleaned out a more comprehensive idea could be gained of the original method of excavating, and a better assortment be secured than at any or all other places on the ridge, both as to color and variety.

Going still south and east from here, and crossing a deep depression drained both to the east and the west, we come to an isolated area, from which spurs extend to the north, east, and west. The first spur reached, that trending north, is on the farm of W. Iden. In a cleared field, about 1 mile from the cross-roads, are five or six large pits; a short distance east of these between 1 and 2 acres of small, shallow ones are found. In spite of their number, it does not appear that much flint has been taken from them. No others are found until the Bowman farm is reached, nearly a mile southeast from Iden's. Here is a spur extending east, on which are 2 acres of pits of a size to compare with those north of the blacksmith shop, that is, from 15 to 30 feet across. There are two spurs reaching from here—one toward the southwest, on which no pits exist; the other southeast, extending about a mile, and terminating on the farm of J. Kreager. Here is about an acre that has been dug over, and from the fragments scattered around it would seem that both black and white flint exist on this point. Before reaching Kreager's a spur goes off in a southern direction on Drumm's farm, but it was never worked.

No more flint exists in this direction. Directly north of the spur on Bowman's farm, and separated from it by a deep, narrow ravine, is a spur on the farm of E. H. Duncan, containing pits of the same character and about the same extent. Immediately east of these, in timber belonging to Joseph Duncan, are five or six large, deep excavations. Continuing north, we come to the depression spoken of as separating this area from the main ridge. Lying partly in this is the farm of Capt. John Loughman. North of his house about an acre has been pretty thoroughly dug over East of this in a bleared field, is about half an acre the flint from which is a dark variety, approaching more nearly to that at the "shaft" than at any other place on the ridge. This field is nearly a mile from the blacksmith shop and close to the town house, located at the point where the ridge road is crossed by the one leading from Black Hand Station to Brownsville. East of the town house is the farm of Samuel McCracken, on the northern and eastern parts of which are two small groups of pits, both comprising about an acre, on a spur extending northward.

Just beyond here commences the before-mentioned break in the stratum of about three-fourths of a mile, the flint next appearing on the farm of Lennox Fisher, about a mile west of the Muskingum County line. Some 300 yards east of his house are three large pits, which the owner calls "ponds," as they generally furnish water for his stock through the summer.

The bottom of these "ponds" is 5 or 6 feet below the surrounding surface; the original depth was at least twice or three times as great, if they preserve the same slope the exposed sides show.

The dip of the stratum is more apparent here than at the western end, as knolls 25 to 30 feet high are in the immediate neighborhood of the pits.

About one-fourth of a mile south of this, on the adjoining farm of William Fisher, a piece of woodland contains 2 acres of pits, some of which are 50 to 60 feet across, but seem to be of less depth than holes of a corresponding size near the cross-roads.

This is the last sight of aboriginal work on Flint Ridge within the limits of Licking county.

The pits being so scattered, and nearly all in dense timber, it is difficult to form an accurate estimate of their extent. Certainly they cannot occupy a smaller area than 60 acres, counting only the space actually excavated.

Half a mile east of the line of Licking and Muskingum Counties, on the farm of Mathias Drumm, are a few pits, one about 60 feet in diameter, the others much smaller; there are not more than a dozen of them.

No others occur until the farm of Jacob Burrier is reached, about 3 miles from Fisher's place. A few small pits exist in the woods southeast of his house. These are on the southern point of the eastern end of Flint Ridge.

About three-fourths of a mile east of Burrier's house, on the Brookover farm, are 2 acres of pits, on the most eastern point of the ridge. About the same extent of ground is dug over on the Varner farm, half a mile north of Burrier's house. Beyond Varner's the spur extends half a mile north, and here is the termination of the ridge in this direction.

To sum up, then, we find these pits reaching from half a mile west to a mile and a half east and from a fourth of a mile north to a little more than 2 miles south of the blacksmith shop at the cross-roads. These vary from 12 to 80 feet in diameter, and some of them, at least, cannot be less than 20 feet in depth.

Then, a small number, some 2 acres, 3 miles east of the shop and near the Muskingum County line.

Finally, a number scattered along in Muskingum County, from half a mile to nearly 2 miles from the line, those farther east being, as a general thing, smaller than the ones in the vicinity of the cross-roads.

They are found on the most northern, southern, and eastern spurs of the ridge, but not within 2 miles of the most western spur.

These distances are only approximate, the winding roads and perplexing sign-boards making it impossible for even those long resident in the locality to form any very correct idea of the distance between two places. It is easy to count up section lines, but when one attempts to follow the roads it will be found that a "mile" is an exceedingly indefinite unit of measure.

The flint around the edges of the whole deposit is not so diversified in color or quality as that in the more central parts, nor does it seem to have been so well adapted to the manufacture of the finer grades of implements.

The amount of work done in excavating is such as would require hundreds of men for many years, even with our superior advantages in the way of better tools, there being from 4 to 8 feet, and in a few places even more, of soil and loose rock to remove, and the flint being so hard that the best drill, according to the well-diggers, cannot penetrate it more than 6 inches without being repointed and retempered. When we take these facts into consideration, and remember that the aboriginal workers had nothing but stone tools, the magnitude of their labor becomes apparent.

The time that has elapsed since this work was done must remain unknown. Efforts have been made to estimate the length of time necessary for trash to accumulate to any particular thickness; but when we know that sometimes an inch and sometimes a foot of leaves may pile up in a single storm, this forms a very unsatisfactory basis of calculation, especially when it is not possible to know the amount of compression that takes place in any given time. "Results" thus obtained are no better than the merest guesses.

On the dirt thrown out from some of the pits are oak trees over 3 feet in diameter, that it is plain have sprung up since the pits were aban-

doned; stumps and trunks decaying on every hand point to trees still older. Timber will not increase in size nearly so fast on this stony ground as it will under more favorable conditions, so that centuries, possibly, have passed away since any work of this sort has been done here.

How these ancients knew where to find the best flint for their purposes, unless indeed these sites were chosen at random, cannot be told. It also remains a question as to how the flint was quarried after its location was determined. No doubt a thorough examination of some of these pits will throw much light upon the methods in use among them for obtaining the raw material.

In Coshocton County, near Warsaw, are some similar pits which have been opened by residents of the locality. In them were found two layers of flint, the upper a dark variety, the lower a clear, translucent kind, which answers to the description of chalcedony. This lower flint seems to have been the kind sought. Traces of fire were plainly visible in the pits, from which the inference is natural that fires were built upon the rock, and that, while heated, water was thrown on it. The stone could thus be broken into pieces. In the bottom of the pits were found bowlders of granite, syenite, and other glacial rock, which plainly showed that they had been used as hammers. No doubt a similar plan was followed at the ridge, and such a supposition is supported by the fact that these hammers, weighing sometimes 40 pounds, are found in the fields around the pits. Although the glacier did not cover any part of the ridge, the western line of Franklin Township coincides very closely with its limit; besides which the Licking River, which is not more than 3 miles distant in some parts, carries down glacial material in the ice every winter, so there would have been nothing difficult in finding abundant material for tools; in fact, the pebbles of which the smaller hammers could have been made are found several miles south and east of the glacier limits, even on high ground, having been carried there by floods or floating ice at the end of that period.

The hammers are found in greatest abundance wherever other signs exist of an ancient "work-shop," or place where the flint was dressed.

Of these work-shops there are two sorts, which are generally distinct, though sometimes the two sorts of work were carried on in one place.

One may be designated as the "blocking-out" shops, the other as the "finishing" shops.

At the first kind, which are always near the pits, it seems the flint blocks were brought to a size and shape convenient for dressing into such implements as were desired. In them are always found the largest hammers, though smaller ones are sometimes picked up as well. Scattered thickly over the ground are angular fragments of flint, such as would result from knocking off corners and projections from the large pieces taken out of the pits, and also from breaking them up into smaller pieces, it being unlikely that a block of such brittle material could be broken up without much waste resulting.

The pieces thus fitted for working were then mostly carried to the finishing shops, though, as above stated, the whole work seems to have been sometimes completed in one place.

These finishing shops are characterized by the smaller fragments, thin flakes, and broken or unfinished implements, very seldom found in the blocking-out shops. The hammers found in them are generally of small size, seldom exceeding 8 ounces in weight, and are of harder or smoother stone than those found in the other class of shops.

The blocking-out in some cases was done at the pits whence the raw material was obtained; but generally a convenient spot was chosen to which all the larger pieces from pits close around were carried, rough worked, and then taken to one of the finishing shops, which are less numerous than the others.

Although these shops are to be found at many places on the ridge, only the more important, those where the greatest amount of work was done, will be mentioned here, as a study of the places named will give a visitor as good an understanding of the method of work as would an inspection of scores of similar places. The relation of the work-shops to each other and to the pits will be readily perceived from an inspection of the map.

The blocking-out shops show material scattered over from 5 to 10 acres in extent; the others, though covering less ground, show a greater amount of work on an equal area.

Of the first sort, then, the principal are located as follows:

On the farm of John G. Loughman, lying along the south side of the ridge road and just south of the western limit of excavation.

Northeast of the blacksmith shop at the cross-roads. The work seems to have been done here as soon as the flint was quarried out, and the fragments are scattered among the pits. Along the side of the road and within a few feet of the shop is a large pile, many wagon-loads, of angular fragments.

Northwest of the pits on Bowman's farm, and again between this shop and Iden's farm, at which place the two kinds of work seem to have been carried on at the same time, or perhaps, better to say, where a portion of the material, after being blocked out, was finished up, while the greater part was carried elsewhere for the finishing touches.

On McCracken's farm, within the limits of the pits mentioned as being north and east of his house.

On the farm of Lennox Fisher, between the pits on his place and those on William Fisher's land, is another work-shop combining the two kinds of work.

At Drumm's, east of Fisher's. Here the flint was blocked out at the pits.

Finally, the last blocking-out place of importance is on Burrier's farm. The stone from the pits north, and those on the Brookover farm east, was carried to what now forms part of several fields, and worked up

A great amount of work is indicated here by the large territory covered by the chips and the number of hammers of all sizes, from 2 or 3 ounces to 15 pounds, scattered on every hand.

In regard to the finishing shops, there is scarcely a farm, or even a field, in all this region where evidences cannot be found of the fact that weapons were finished up, or at least dressed to some extent. Partially finished or broken specimens, spalls, and flakes may be gathered almost anywhere; unfortunately, such are, now, about all that can be picked up. Collectors from various places have been here so often and in such numbers, and have paid boys such fancy prices for "flints," that the ground is kept pretty well searched over. Indeed, when the ground is plowed in the spring, boys hunting "flints" are almost as numerous as the blackbirds following the plow.

The locations of the more important ones will be given:

On the Burrier farm is a knoll of about 10 acres, south of his house, on which the flakes are scattered thickly. The finishing up of nearly all the flint quarried in Muskingum County (except that from the few pits on Drumm's place) seems to have been done here.

Some 30 rods east of the pits on the Drumm farm is a strip of high ground containing some flakes and spalls—not many, but still in as great quantity as the limited number of excavations would lead one to expect.

In addition to the shop named on Fisher's place as combining the two kinds of work, is one of small extent, on a knoll north of the three pits, and another west of this, in what is now an orchard, where considerable work has been done.

Just east of the town house is a small area where the flint from the pits in that vicinity seems to have been finished. Southwest of this a limited space on Capt. John Loughman's farm has flakes quite thickly spread.

On Iden's farm is a field of 10 acres where abundant chips and flakes show that on this spot the finishing touches were given to all the flint from his, Duncan's, and Bowman's farms.

At John G. Loughman's house is about 1 acre thickly covered with pieces of all the colors to be found in this region, while on the same farm, some 40 rods west, on the point containing the large, deep pits, is the most interesting spot of all. Hundreds of implements, in all stages of finish, have been found here, and each fresh plowing seems to expose them in undiminished numbers. As deep as a plow can go these specimens are found, and in such numbers that the jingling noise made by them sounds as though one were plowing through a lot of castings. At the side of the field nearest the edge of the hill the spalls are said to have been piled up in a mound before cultivation scattered them, as though the "ancient arrow-maker" had either thrown the fragments on every side of him, and thus gradually elevated himself, or else had heaped all the flakes and unfinished or broken specimens into a single pile. Over an acre

of this point has been plowed this year, and the remains of "primitive industry" cover all this area. How much more may be hidden under the soil formed by vegetable growth since the shop was abandoned is uncertain, but it seems reasonable to suppose that all the part in which no pits are found, some 4 acres, may have been left by the aborigines as a place in which the work might be completed. On the part that has been plowed there is about half an acre in which the flint amounts to four-fifths of the whole; that is, if all the soil could be put in one pile and the flint chips in another, this would be the proportion of each.

Nearly all this is in small flakes and spalls, chipped off in finishing. Very few angular blocks or fragments are found, and such as do occur are those which were carried from elsewhere, but on which, for some reason, the finishing process had not begun. This is the only workshop on the ridge where may be found the flint "coves" from which were flaked off long, thin splinters to be used as knives, perforators, lancets, and the like.*

On J. Kreager's farm is a shop just north of the pits and on the side of the hill. Both angular fragments and thin flakes may be found here, showing that the rough blocks were fully dressed out before being carried away.

Smaller shops may be found on J. S. Loughman's land, just at the western edge of the break in the stratum, and on Cook's land, a short distance southwest of Capt. John Loughman's.

The work of making these implements, then, seems to have been thus:

The aborigines (meaning thereby Indians, Mound Builders, or whatever other name may be assigned to the people who did this work) knew that by digging into the unweathered bed-rock a quality of flint could be obtained better suited to their purposes than that which could be procured along the outcrop. The dirt was cleared away, by being carried out in baskets or skins, until the flint was exposed. Cleaning out a space sufficient for working purposes, a fire was built on top of the rock, and when it was heated water was thrown on it. This would cause the rock to crumble, and on clearing out the fragments a fresh surface of flint would be exposed around the hole thus made in it, from which pieces could be broken off with the large bowlders found in the vicinity. A question presents itself here, "If this method was used, why did they not follow the flint stratum, once they had found it, throwing the dirt behind them, instead of opening so many fresh holes?" The only answer to be given is that they did not, except in a few instances, and that is all we know about it.

The pieces thus obtained, if not already small enough, could be again

* On digging in this shop, after the above was written, it was discovered that the layer of chips was not so thick as it was supposed to be; at any point in the field soil free from flint could be found at not more than 16 inches below the surface. Still, an immense amount of work has been done here.

broken into smaller ones of a convenient size for handling, and taken to one of the blocking-out shops. Here they were broken into pieces of such size as would be best adapted for the form of weapon desired, the faulty pieces rejected, and perhaps the largest blocks chipped into a rough outline of its final form. Next, it was taken to the finishing shops, where the smaller hammers were brought into play to chip off as much as was possible by such means, after which the weapon, if intended to be completed here, was flaked off, by means of pressure exerted with a piece of bone or horn, until it reached an outline as regular and a finish as smooth as its maker desired or was able to give.

The well-diggers say that the flint can be got out in solid pieces measuring 12 to 18 inches each way; that it has a smooth, oily look not found in those pieces exposed on the surface; and that it is much tougher and harder to break. This "toughness" is probably due to the moisture in the stone, as the statement has been made that flint when first got out of the ground can be flaked off with but little difficulty, while after even a short exposure it becomes brittle and is liable to break in any direction. Whether, when thus dry and brittle, it could be restored to its former state by immersion or burial is a question for experiment.

One of the old-timers who has been living here for nearly fifty years says that when he first came to the country the old-fashioned flint-lock muskets were in general use, and that the hunters were in the habit of collecting pieces of flint and soaking them in oil for some weeks before using them. This caused them to last much longer; a flint that would, by shattering, become useless in one day, could by this means be made to last for weeks. Is it not possible that the aboriginal workers had some such process by which they could render their work easier and more certain?

Careful investigation of these finishing shops gives rise to another belief, namely, that very few weapons, as compared with the great amount of flint used, were ever fully completed here. The great number of roughly finished specimens found here, when there seems to have been no reason for having discontinued work on them, and the great quantities of similarly shaped pieces from this locality occurring at places quite distant, show that the majority of the pieces worked here were brought nearly to the required shape and that it was left with the final owner to give each one such degree of fine finish and symmetry as suited him. There are many places remote from any flint deposit where flakes and spalls are found in abundance, showing that flint implements of some description had been dressed on the spot.

The immense amount of work done at Flint Ridge, and the widely separated points at which material from here has been found, may be explained in two ways:

First, that some particular tribe or race owned this region, and carried on for generations, or perhaps centuries, a regular traffic in such

unfinished weapons. It is stated in many works upon our modern Indians that each tribe has a particular form of arrow-head or other weapon, so that one found at a distance from a settlement shows to an experienced observer just what tribe has been represented in the vicinity. As it is highly improbable that any one tribe could have utilized the great quanity of flint that has been taken even from this one locality, there can be little doubt that a regular trade was carried on with neighboring tribes, or even with those at a distance; and in this view it is likely that the separate blocks were brought to the smallest compass compatible with their ultimate use, in order that as little useless material as possible would have to be carried away. And the same holds good with the so-called "leaf-shaped arrow-heads," even those dressed as smoothly as we sometimes find them; in support of which the following is offered:

An examination of flint weapons shows that there are two general forms of the upper part or point—the straight sides, as in Fig. 1, or the curved sides as in Fig. 2. The angle of divergence of the sides may vary

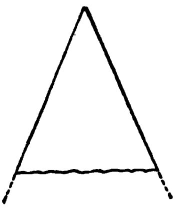


FIG. 1.

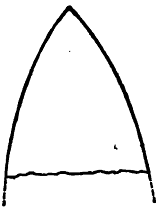


FIG. 2.

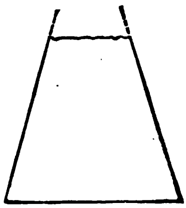


FIG. 3.

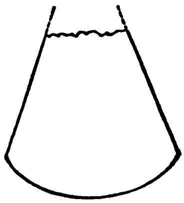


FIG. 4.

considerably, but this does not affect the subject.

Now, in the many specimens which have been found in various factories, particularly the one under consideration, it may be noticed that nearly all which have been dressed as smooth and thin as they can be have two general forms of the base—the square, as in Fig. 3, or the curved or circular, as in Fig. 4.

Very few, comparatively, are found in which the barbs or tangs are finished out. Take almost any arrow-head, restore its outline by filling the chipped out places with wax (the experimenter will probably be surprised to see what a small quantity will be required), and the weapon will be restored to one of the forms made possible by a combination of the straight or curved sides with the straight or curved base.

A few such restorations are here given:

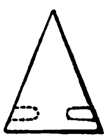


FIG. 5.

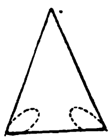


FIG. 6.

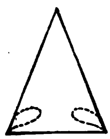


FIG. 7.

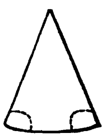


FIG. 8.

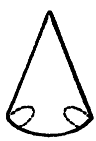


FIG. 9.

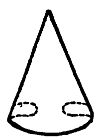


FIG. 10.

Similarly for those with curved sides.

These facts, which may be noticed at other places as well as at Flint Ridge, give much support to the theory of a general traffic in weapons by one tribe with other tribes, and goes far toward explaining the occurrence of the great numbers of unfinished weapons, flakes, and spalls of any particular flint scores or hundreds of miles from the place where it could have been quarried.

Before giving the second way in which the facts may be accounted for, a little digression is necessary.

As is well known to all who have perused the various works on archæology, Licking County is not surpassed by any equal area in the country in the size, number, and complicated arrangement of prehistoric earthworks. More stone mounds, too, are found in its limits than in any other one county, in Ohio at least.

From the immense works at Newark a system of mounds and other structures stretches towards the Muskingum Valley on the east and the Scioto on the west, so that by means of semaphoric communications the whole region could be appraised in a short time of any unusual event.

Notwithstanding this, the whole of Flint Ridge, despite its evidence of long occupancy, shows few remains of this nature.

The line dividing Franklin and Hopewell Townships crosses a stone fort. The hill-top is level and gradually widens out as it extends eastward from the fort, which incloses about 10 acres and is built upon the point of the hill in such a way as to reach the brow on the northern, western, and southern sides, and is admirably situated for defensive operations, and also for commanding the valleys leading from the ridge westward. Within it are two mounds, one of earth, the other of stone, not more than 20 yards apart. Both have been opened, but without results. The stone mound and the fort are constructed of flint blocks gathered up from the outcrop just below the top of the hill.

In the field containing the blocking-out shop, southwest of the blacksmith shop, is a circle of about 35 yards diameter; a few rods west of the blacksmith shop is, or rather was, another of about 50 yards; and on Bowman's farm, west of the pits, was another, whose size could not be learned. Both the latter have been plowed down level with the surrounding surface. They all seem to be village sites or permanent encampments, being on the highest ground in the vicinity.

On Captain Loughman's farm, in the finishing shop east of the house, a mound formerly stood which has been plowed down. From no point on the ridge can a more extended view be obtained than from the site of this mound. Hills in the three adjoining counties of Perry, Muskingum, and Coshocton are plainly visible, and the country nearer at hand is spread out like a map before the observer.

These are all the places, so far as known, that indicate any permanent settlements. Diligent search failed to reveal any traces of pottery or other domestic implements, nor does it appear that any relics have

ever been discovered except such as may have been lost or abandoned by wandering, hunting, or exploring parties.

While on this part of the subject it may be stated that the "trail" from Grave Creek, West Virginia, to the lakes led past the captain's and close to the cross-roads. Old settlers speak of seeing the Indians follow it many years ago.

A so-called "furnace," which many of the inhabitants believe to have been used by the Indians to melt gold out of the flint (every man who comes to the country will be assured that this is "a solemn fact"), located half a mile south of the captain's, proves to be an old camp site. Being close to three large springs, it would naturally be selected by hunters and movers, and was much used, a large amount of burned sandstone being scattered around, of which fire-places were constructed.

A "mound" on the Muskingum line proved to be a spot where an excavation had been begun but soon abandoned; a crescent-shaped hole has the dirt from it thrown on the surface between the horns. Most probably made at an early day by whites seeking material for millstones.

To return to the argument: This scarcity of the evidences of permanent settlement on a scale commensurate with the amount of work done offers another solution of the unfinished state of so many implements, which is this:

It is well known that the celebrated "red pipe-stone quarries" were held as sacred and neutral ground by all the tribes which were accustomed to gather there for the purpose of procuring this rare and, to them, valuable stone. No matter what feuds may have existed between tribes, or what deadly enmities may have been held by individuals, when workers met in these quarries it was always in a state of peace, even if their differences would not allow friendly intercourse.

Some such feeling as this may have influenced the natives of this section of the country. With that disposition characteristic of the superstitious, nations as well as individuals, to attribute everything by which they are benefited to the direct and friendly interposition of a beneficent Superior Being, it is easy to believe that these people may have held this Flint Ridge as a sacred gift from their Great Spirit. All the different tribes may have resorted to this place to obtain material from which to fabricate weapons, and also, it may be, to secure the more brilliant stone for making totems or insignia, or for some tribal or religious ceremonies.

The stupendous works at Newark, and the connected system of mounds, &c., could have been built only by a nation that possessed the territory for a great length of time and were in large numbers. They would claim dominion over all the country round for many leagues, except perhaps this sacred ground, if so it was held, and would jealously guard their territory against the hunting parties from other regions; and although they would not, from religious motives, molest outside parties engaged in procuring flint, yet when these same parties went

beyond their allotted boundaries, they would, like more modern people, find that a decided limit can be given to conscientious scruples by personal interests; hence it would behoove them to secure their flint as quickly as possible and get back to their own hunting grounds, unless, indeed, they had the means to supply themselves with provisions from the owners of the surrounding country, for supporting themselves, in case a longer sojourn was desirable. So that they would chip their flint to a portable size and shape, and carry it thus with them to such points as they chose, and there take all the time necessary for dressing and finishing it up.

The caches of so-called "disks," "scrapers," "leaf-shaped implements," "turtle-backs," or "hatchets," as they are variously named in so many localities where they are found, which may be regarded as nothing more or less than such unfinished pieces, render this theory plausible; and it certainly loses no strength if we accept the statement quoted some pages back that "fresh" flint is much more readily worked than "dry." Burying it in the ground would allow it to remain in working order much longer than if it were exposed to the atmosphere.

The finely dressed arrows or knives sometimes found, and the few "circles" in the vicinity, do not militate against the theory; in fact, they rather strengthen it; for such of the natives as lived within a short distance could well spare the time necessary to complete their work while they were about it, and the defensive position indicated by the fort and "circles" is only such a precaution as would naturally be taken by a settled people who were compelled to allow strangers or even enemies to remain so near them unmolested. Three hours' time, or even less, would have allowed a treacherous, hostile party to reach the Newark works from the Ridge, and it was only a matter of ordinary prudence to keep a look-out for such a contingency. The position of the fort, too, supports this view, being located, as it is, so far west of the nearest point to their settlements where any work was done, although a limit had been set past which none were allowed to go.

If it be objected to all this that it makes the Indian and the Mound Builder the same person, let it be remembered that no one has yet proven that the Indian was *not* a Mound Builder, or that the Mound Builder did not do this work on Flint Ridge.

Whether there is anything in these two "explanations" which possibly "do not explain," or whether a combination of both may better suit the case, or whether, finally, the facts must be explained by a new hypothesis, archæologists may determine. The writer, not professing to be posted in the science, simply submits such thoughts as will suggest themselves to any one who may go over the ground carefully; and if these observations will throw any light upon this interesting subject, or afford any information, let it be taken for what it is worth.

Strict accuracy is not claimed for the accompanying map. A person, without instruments or assistance, attempting to get area and distance

on strange ground, much of which is covered with heavy timber and dense undergrowth, may be pardoned a few errors.

The roads and farms are taken from a county map; the pits, workshops, &c., are put as near as possible in their true positions, but are somewhat exaggerated in area, that they may be more easily located; and any one with this map will experience but little difficulty in finding anything of archæological interest on the Ridge.

Any one wishing to make a personal investigation will do well to begin his work by calling on Capt. John Loughman, living near the cross-roads. He has hunted over these hills for more than fifty years, and every field is familiar to him. He takes pleasure in giving information to the seeker of knowledge.

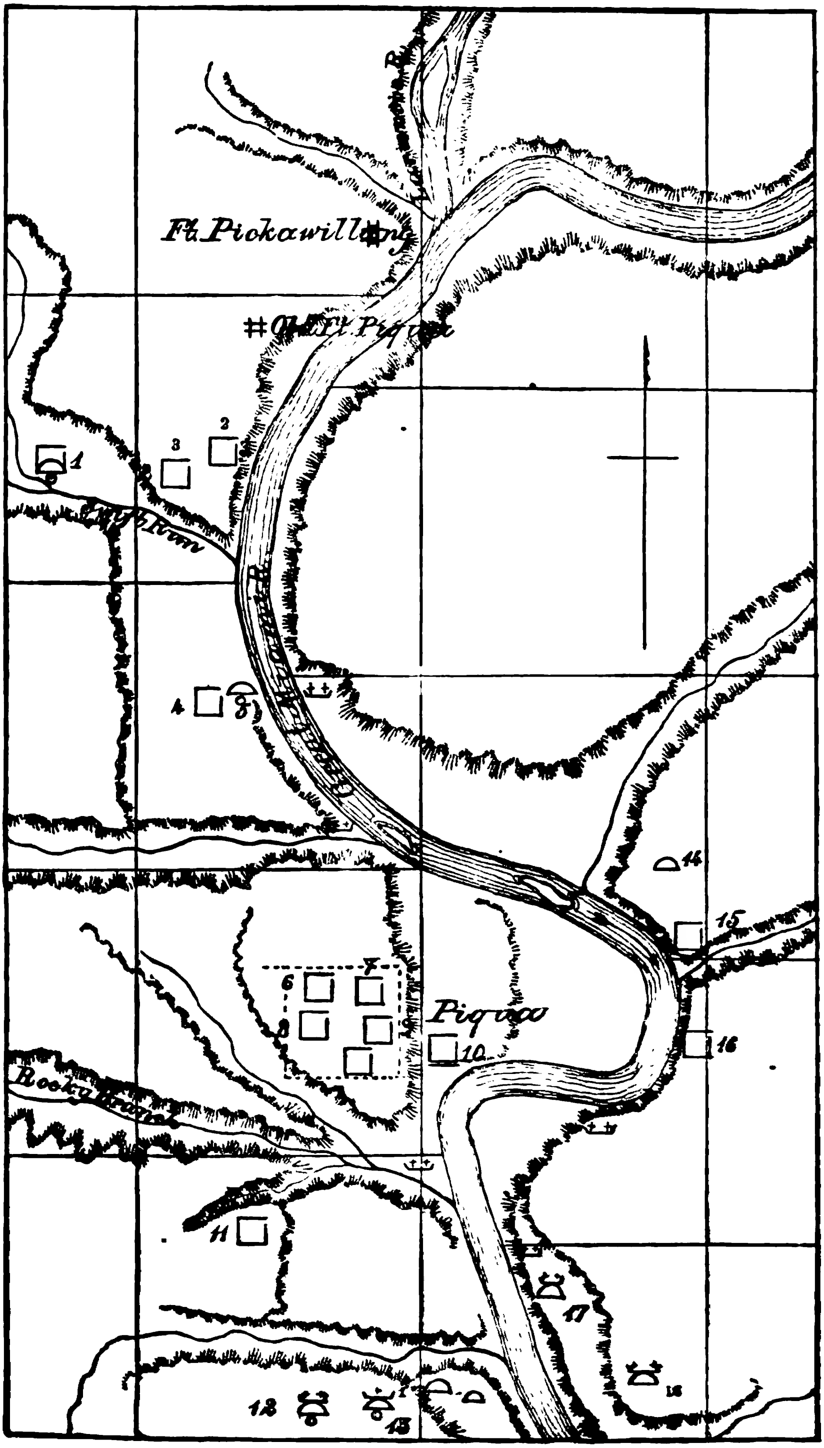
EARTHWORKS AND MOUNDS IN MIAMI COUNTY, OHIO.

By E. T. WILTHEISS, *of Piqua, Ohio.*

The accompanying map represents Washington and part of Spring Creek Township, Miami County, Ohio, in which are located all the ancient works that were in existence when the Europeans made their first appearance in that locality. The works are marked with figures to identify them in order.

No. 1 is a large ellipse whose axes are respectively 1,500 and 900 feet, and incloses, according to Col. John Johnston, who was the former owner of the place, 17 acres. The wall is made of bowlders, all water washed, and, no doubt, they were gathered from the bed of the East Miami River. The work is located 3 miles north of Piqua, Ohio, and is 30 feet above the level of the valley of the river. The foundation of the wall is 10 feet wide at the base. The wall which was, at the appearance of the settlers in 1797, about 4 feet high, has fallen down, and the bowlders lie scattered all over the field. The present owner is destroying it as fast as possible, as he has the field under cultivation.

The figure of the ellipse deviates in some cases from a strict regularity to accommodate itself to the surface of the country as it then was. There was a large spring on the northeast in the fort which was walled with bowlders. About 30 feet southwest from the spring stands a bowlder on end 3 feet in height. On the south end of the fort is a mound 240 feet in circumference and 5 feet high. This mound was surrounded by a small ditch, which was paved with small bowlders. It took one man a week to remove this pavement. In May, 1880, the writer made an exploration of the center of the mound and found it to contain a sacrificial altar. After digging through a foot of soil, a stratum of yellow sand was encountered, 10 inches thick; then 6 inches of ashes mixed with burnt bones. This stratum of ashes was pressed in such a solid mass



Remains near Piqua, Miami County, Ohio.

that it required a pike to break through it. After the removal of the ashes, 19 inches of clay burnt red were met with. The excavation was about 6 feet square. There is a large stump of a tree standing a little to the north of the center of the mound. On the west side of the fort are three gateways 8 feet wide, which are covered on the outside by a stone wall 10 to 12 feet long, and 6 feet thick. There are also three small ravines running down to the valley below in front of these gateways, which no doubt were excavated by human hands. On the west wall are standing at present some very large trees.

No. 2 is a small circular fort situated 200 yards southeast of No. 1. The height of the wall is at present about 18 inches, but formerly, no doubt, it was much higher. This inclosure has a ditch on the inside, and gateways facing fort No. 1, and is about 150 feet in circumference.

No. 3 is a similar structure, and is located about 200 yards east of No. 2. This embankment has two gateways, one on the east and the other on the west, 8 feet wide. The wall is about 4 feet high and slopes towards the gateways. This also has a ditch on the inside. This work has never been disturbed. It is about 200 feet in circumference and is fenced and covered with sod.

No. 4 is located 1 mile south of No. 1 and situated on the second bottom. It is 300 feet in circumference, with an entrance on the southeast side, 10 feet wide. Its embankment is at present about 2 feet high and 8 feet wide, which the plow lowers every season, and its wall will soon be erased from the surface. This also has a ditch inside.

No. 5 is a mound situated 300 yards to the northeast of No. 4. This mound was 240 feet in circumference, and was formerly about 9 feet high, but at present is almost obliterated. An exploration was made by running a ditch from south to north to the center of the mound, and it was found to contain an altar composed of burnt clay. This was covered with ashes, charcoal, and burnt bones, 3 inches thick. On this was a layer of clay, then alternate layers of clay and charcoal 5 feet thick, each charcoal stratum being about 1 inch in thickness, the whole covered with clay and gravel mixed, 2 feet thick. West of the altar were found human remains, viz, a skeleton lying with the head towards the southeast imbedded in clay; the skull bore the appearance of having been crushed with a blunt instrument. Fragments of the skull were within the cavity near the surface. Broken pottery similar to that found in Kentucky occurred.

Nos. 6, 7, 8, 9, and 10 are altogether obliterated and were located within the present limits of the city of Piqua, Miami County, Ohio, all within an eighth of a mile of the river. These works were described by Maj. S. H. Long.

No. 11 is situated 1 mile southwest of the center of Piqua, on the upland. It is an ellipse 60 feet wide and 100 feet long, with ditch on inside and one gateway on the north. This work has been almost ob-

literated by the plow. There is a spring at the foot of the hill in front of the gateway.

Nos. 12 and 13 are stone mounds about 2 feet in height and 100 feet in circumference. From No. 12 were taken a great many human remains, and from No. 13 a skeleton, a stone ax, and a slate-stone plate perforated with one hole.

No. 14 was another mound, which is now entirely obliterated.

No. 15 is a circular earthwork, with a ditch on the inside. The embankment, which is about 3 feet in height and 5 feet wide, is situated on a high bluff off the Miami River, and can be distinctly traced.

No. 16 was another circular earthwork, and there are at present no traces of it, for the Dayton and Michigan Railroad runs over the spot where it was. It was about 300 feet in circumference, with a ditch on the inside. There is a spring on the west of the work, about half way down the bluff, which never fails.

No. 17 is another stone mound 150 feet in circumference and is now 2 feet high, but formerly was much higher. The former owner has removed a great deal of the material of this mound for the purpose of burning lime. There are a great many human remains beneath this mound.

No. 18 is a large mound, covering nearly an acre of ground, and at present is 21 feet high. There is a house built on this mound, the owner of which informed the writer that in digging the cellar he encountered ashes, charcoal, and remains of burnt bones. This mound cannot be thoroughly examined, on account of the house, which stands in the center of the mound. The map is marked with crosses where human remains are found; also the village sites.

There are remains of works in other townships.

In Concord there is a mound 155 feet in circumference and 5 feet high, truncated. In Newton Township there is a one-half circular work, 700 feet in circumference, 240 feet in length, and 6 feet high. There is a ditch on the inside and outside, sloping towards the ravines, where the embankment ends. The wall of earth faces the west. Also one circular work 300 feet in circumference. These two works are located on the west bank of the Stillwater River, on Section 19, Newton Township, Miami County, Ohio, and are covered with timber. They are situated on a bluff 60 feet above the river. There is a ravine running from the southwest and another from the northwest, and in the fork between these ravines the largest of the works is located.

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